THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
VOL. IX, NO. 4 MAY, 1928

This race called ~ *BUSINESS!*

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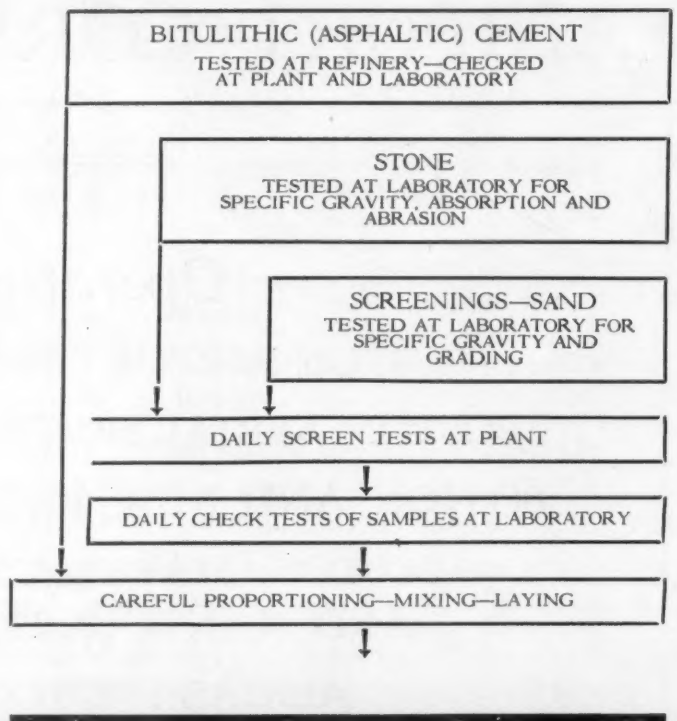
BITULITHIC (ASPHALTIC) CEMENT
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TESTED AT LABORATORY FOR SPECIFIC GRAVITY, ABSORPTION AND ABRASION
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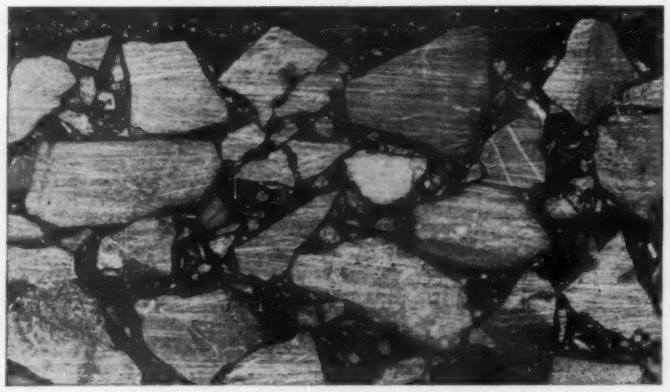
TESTED AT LABORATORY FOR SPECIFIC GRAVITY AND GRADING
DAILY SCREEN TESTS AT PLANT
DAILY CHECK TESTS OF SAMPLES AT LABORATORY
CAREFUL PROPORTIONING—MIXING—LAYING



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Vertical cross section. Either crushed stone or gravel may be used as coarse aggregate

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WARREN BROTHERS COMPANY

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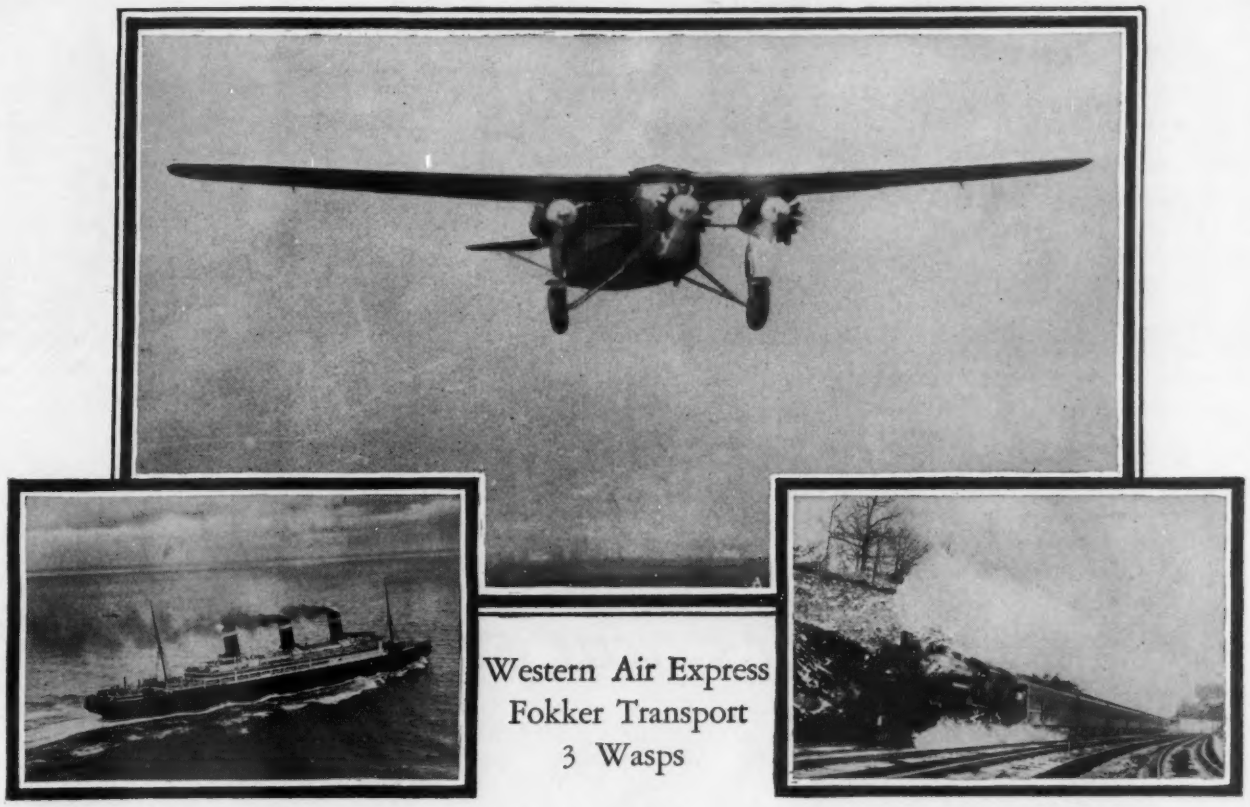

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3 Wasps

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The 20th Century Limited

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THE TECH ENGINEERING NEWS

Volume IX — CAMBRIDGE, MASS., MAY, 1928 — Number 4

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New "Straight Line" Plant

NATIONAL CARBON COMPANY, Inc., Fostoria, Ohio

This new industrial plant of the National Carbon Company, Inc., at Fostoria, Ohio, was designed and built complete by Stone & Webster, Inc. The arrangements of the following buildings insure a straight line flow from raw materials to finished products:

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SAN FRANCISCO, Holbrook Bldg.
PHILADELPHIA, Real Estate Trust Bldg.

MAY 28 1928

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THE TECH
ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IX MAY, 1928 NUMBER 4

Aeronautics in Technical Schools and Universities

The standards influencing the best in aeronautical study and instruction

By EDWARD P. WARNER '17
Assistant Secretary of the Navy for Aeronautics
Head of the Department of Aeronautical Engineering
Massachusetts Institute of Technology

THE dedication of the new building erected to house the aeronautical course by the generosity of Daniel Guggenheim, the Maecenas of aeronautical science, comes as a turning point in the history of aeronautical studies at the Massachusetts Institute of Technology. It will bring gratification to all the alumni of the Institute, and to those who in Government departments have been concerned in sending students there for specialized aeronautical training during the last dozen years, that the oldest advanced course in aeronautical engineering in the United States is at last to be housed in appropriate, dignified, and adequate quarters of its own. Under improved physical conditions it is to be hoped and expected that the work done in that field may improve upon and expand beyond anything attempted in the past.

In the liberality of their benefactions to institutions of higher education, Mr. Harry F. Guggenheim and his fellow trustees of the Guggenheim Fund for the Promotion of Aeronautics, have manifested agreement upon a great and fundamental truth. Scientific development depends upon the man. The machine is neither self-creating nor self-maintaining. Natural law does not expose itself and its implications to the light of day, as a nut is cracked by the frost. The shell of obscurity must be torn away by well-directed human effort.

In the human element in progress it is not enough to wait upon genius, and genius alone does not suffice. The essence of science is that it is evolutionary. Each generation builds upon the topmost story of its predecessor's pile. Genius is no less dependent upon a well-rounded training for its full flowering than is mediocrity. If you seek the master-key to scientific progress you will find it in the best educational method and facilities. The trustees of

Courtesy *Technology Review*

EDWARD P. WARNER '17

the Guggenheim Foundation have sought the key to the continuing future advance of aeronautical science, and they have taken technical education as the perfect foundation whereon to build. The Institute may well be proud of its selection as one of the schools to be assisted in carrying on its aeronautical work, and the new Guggenheim aeronautical building will stand as a lasting symbol of a responsibility imposed and assumed for making, through research and through the work of those who graduate from its courses, positive and solid contributions to the up-building of aviation in the practical service of the American people and of all the peoples of the world.

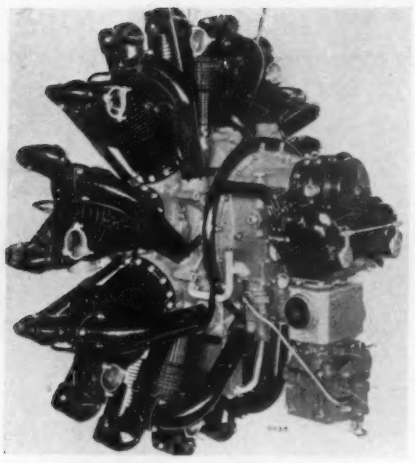
Aeronautical engineering makes exacting and diversified demands upon those who practice it. In no branch of professional employment dependent upon the application of natural law is a sound knowledge of fundamental theory more vitally important than to the thoroughly qualified airplane designer. In no other profession, surely, do problems combining practical and theoretical elements present themselves for solution in more novel and varied forms. The training of the aeronautical engineer should be no primrose path, and those who meet the standards that ought to be imposed, whether in collegiate course, in the services of the Government, or in commercial life, should be able to flatter themselves upon belonging to a *corps d'élite*. It is altogether proper that in the planning of educational facilities and their use emphasis should be laid upon the necessity of high quality in the human product. Men possessed of technical qualifications in aviation are already needed in considerable numbers, and the demand will increase, but the preeminent responsibility of the technical school of high repute is the training of engineers fit to lead the way to the

(Continued on page 186)

Aircraft Power Plant Development

The trend of design during the past year, with emphasis on the air-cooled engine

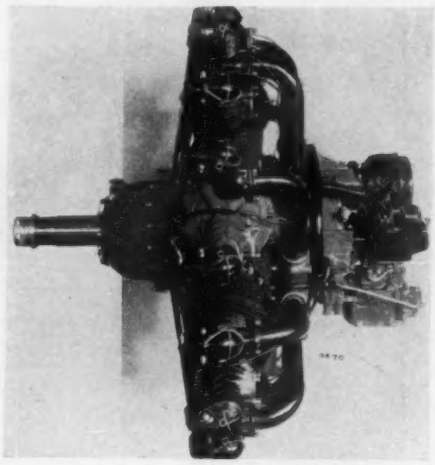
By GEORGE J. MEAD
Vice-President
The Pratt & Whitney Aircraft Co.
Hartford, Conn.



P. & W. "WASP" ENGINE
Three-quarter rear view of the military type. 450 h. p., 2100 r. p. m. Weight, 660 pounds.

THE outstanding power-plant achievement of the year is the proof of the superiority of air cooling. Not only was this demonstrated by the transoceanic flights, but by the operation of the major part of the transcontinental mail, which, with the same power, air cooled, is carrying twice the payload formerly carried by the water-cooled engine. In this country the Vee or in-line water-cooled type of engine has given way to the radial, which is available in 100, 200, 400 and 500 h. p. units. Among the manufacturers of these engines are the Wright Aeronautical Corporation, The Pratt & Whitney Aircraft Company, Fairchild Airplane Manufacturing Company and the Ryan Aeronautical Company. Some of these engines are furnished geared, as well as direct drive. Both the Wright "Cyclone" and the Pratt & Whitney "Hornet" are being developed with epicyclic gears. There is only one new water-cooled engine available. This is a 600 h. p. Curtiss twelve-cylinder Vee type, built both as a direct and geared engine, but primarily for military purposes.

Abroad the tendency has been toward air-cooled engines, but except for England and France, practically no engines of this type are in regular production. Most British engines are of the radial type, including five, seven, nine and fourteen-cylinder models. Two four-cylinder in-line engines of approximately 80 h. p. are available for light planes. Twelve-cylinder Vee water-cooled engines are still being produced and used in large quantities, as well as the W type engine, also having twelve cylinders. It was with the W type that the British were able to regain the famous Schneider Cup with a speed of nearly three hundred miles an hour. Aside from a British Jupiter air-cooled radial built in France, there has been to date very little production of air-cooled engines in Europe. Germany, due to the restrictions imposed upon it, has had very little opportunity to develop air-cooled engines. For this reason some of the prominent engine builders have obtained licenses to build well-known American and British air-cooled engines. The B. M. W. Company have obtained the right to build the Pratt & Whitney engines, while the Siemens-Halske Company have the license for the British Jupiter engine. In general, European power plants are becoming air cooled, just as has been the case in this country.



P. & W. "HORNET" ENGINE
500 h. p., 1900 r. p. m. with 2–1 reduction gear.

A large number of small experimental engines are being built in this country. These range in power from 80 to 130 h. p. The field for such engines is in small privately owned planes that have previously been powered with the OX motor. All sorts of types are to be found, including four cylinder in-line, five, six and seven-cylinder radials and the eight-cylinder Vee. Some of these are new designs and others air-cooled editions of old style water-cooled engines. The principal urge at the moment is low first cost regardless of weight or durability. By taking the weight of the OX engine plus its cooling system as approximately 500 lbs., a weight of nearly 4 lbs./h. p. is permissible for an air-cooled engine developing 130 h. p. and giving the same plane performance. This gives a large latitude in design and the quality of the materials used. As has been the case with the low-priced motor car, the public will demand value for its money just as soon as it becomes educated in aviation engine values. When this happens, the quality of these small engines will necessarily be much higher. In the larger powers two row radials and inverted Vee engines are being developed. Both of these types are considerably heavier and more costly than the radial, but have the advantage of less frontal area. Whether this

BOEING MAIL PLANE
Equipped with a "Hornet" engine. This is now one of the standard mail carriers on the transcontinental route. Continual climatic changes require the highest kind of performance.

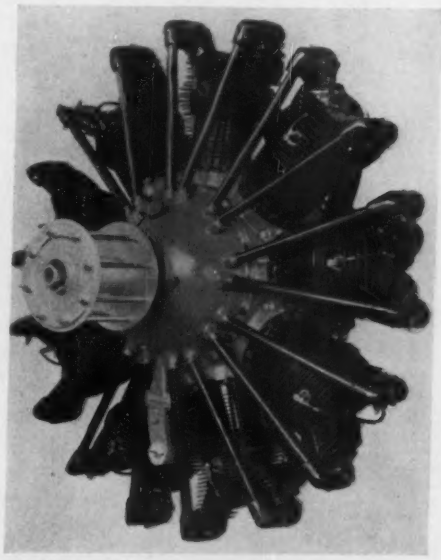
FOKKER WESTERN AIR EXPRESS. "WASP" ENGINES
The reliability of these engines is one of the factors which make aircraft transportation the effective utility it is today.

necessarily means less drag remains to be seen, as with both of these types the air stream must be turned through a total of 180°. Their major problems are cooling and distribution, which are probably most accentuated in the Vee. If larger power units than 600 h. p. are required, these types, or others involving more than twelve cylinders, will be necessary.

The dollar yardstick of commerce is being applied to aircraft power plants. Already its influence is being felt. Heretofore the military ideas prevailed, and cost was a secondary consideration. This resulted in expensive, complicated, high-powered and relatively short-lived power plants, all to gain a little in performance regardless of cost. Having been brought up under these conditions, it is hard for the individual company to change its viewpoint. Change they must, as evidenced by the fact that commercial aviation refused to consider good war-time water-cooled power plants at a low first cost and purchased instead new radial engines. Why? Because the radial could carry nearly twice the payload at the same speed and was much cheaper to operate. Our present problem is to decrease our losses, principally in the propeller and in the drag of the power plant, and reduce depreciation and maintenance costs. The losses are of serious magnitude, but fortunately capable of material reduction. In a 400 h. p. power plant it is not unusual to lose 120 h. p. in the propeller, of which at least half may be salvaged through propeller design and proper speed of operation. This latter may require reduction gearing or variable pitch propellers.

Engine drag has not, up to this time, received much attention. With the water-cooled engine this was not of importance, as the engine was completely enclosed in the fuselage. Each cylinder of an air-cooled engine is its own radiator and therefore must be exposed to the slipstream. The drag of the individual cylinders need not be as much as that of a tunnel radiator. Heretofore the engineers' attention has been wholly devoted to making the cylinder cool, and consequently a good deal of improvement is possible. Savings of this kind are reflected in fuel economy or higher speed, as also are those from increased propeller efficiency.

The largest items of operating cost are depreciation and maintenance. A low first cost is not nearly so important as long life in reduction of depreciation. This means that longer and longer life must be built into the power plants. Here experience is the only guide, as it is next to impossible to predict wear or fatigue failures and thus guard against them. Duration testing and close



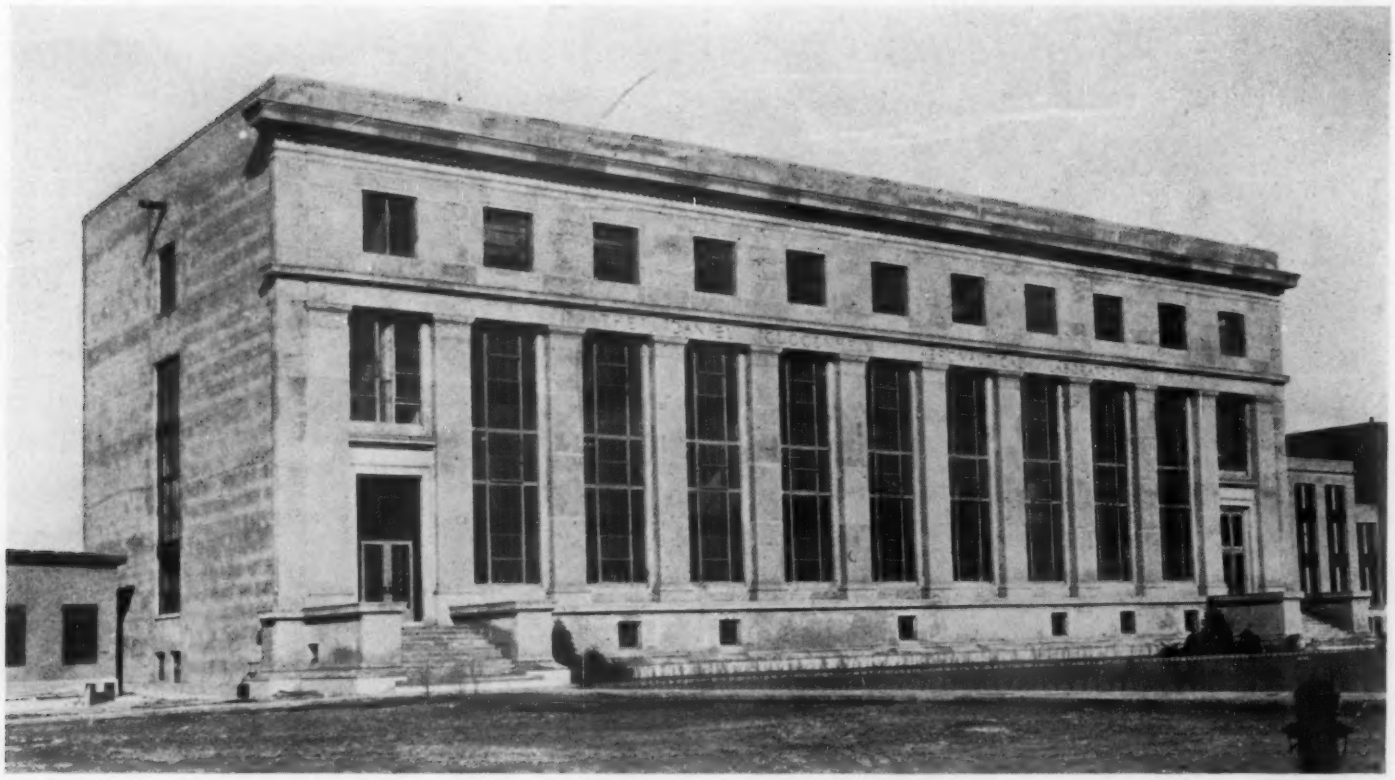
P. & W. "WASP" (COMMERCIAL)
Three-quarters front view.
425 h. p., 1900 r. p. m., 660 pounds.

coöperation with users gives a background to a design that no amount of ingenuity can equal. Power-plant life must be measured in terms of thousands of hours. So far, 1,500 to 2,000 hours' life has been considered good. This means 150,000 to 200,000 miles of service, which compares favorably with the motor car, especially considering the relative weight per horse power of the two.

Maintenance cost is built up of the number of overhauls required during the life of the engine, and the labor and parts cost attendant thereto. An engine with few cylinders and simple inexpensive parts, which are readily accessible, is greatly to be desired. To this must be added durability so that few overhauls are required. Each detail must be studied from the wear standpoint. This involves proportions of parts, lubrication, rigidity and cooling. The weak links in the mechanism must constantly be improved so that the combined life will be better and better. At present the overhaul time is three times as good as with war-time engines. Three hundred hours between disassemblies is expected. This is equivalent to approximately 30,000 miles in the mail service. Parts replacement cost on twenty-five engines in this service averaged less than $14 per engine with a labor cost of $50.

Reserve power has become an essential requirement for air transportation. Heretofore we were accustomed to equip our ships with just enough power for the performance required. With water-cooled power plants surplus power was prohibitive as its weight reduced the payload so much. With the lighter air-cooled engines considerable reserve power is possible without much penalty in the form of reduced payload. Besides equipping planes with surplus power in the form of a large single engine, most passenger planes are being equipped with three engines of sufficient power to permit entirely satisfactory operation on two engines. To maintain schedules regardless of weather conditions and increase the operating life of the power plant, it is desirable to operate normally at from sixty to seventy per cent of rated power. The reserve is thus sufficient to take care of most emergencies. Trains use only forty per cent of their power, while ocean-going vessels use about sixty to seventy per cent. Air-

(*Continued on page 164*)



THE DANIEL GUGGENHEIM MEMORIAL BUILDING,
The new aeronautics laboratory as observed from upper Massachusetts Avenue

Daniel Guggenheim Aeronautical Laboratory

A description of the most recent addition to the Technology buildings

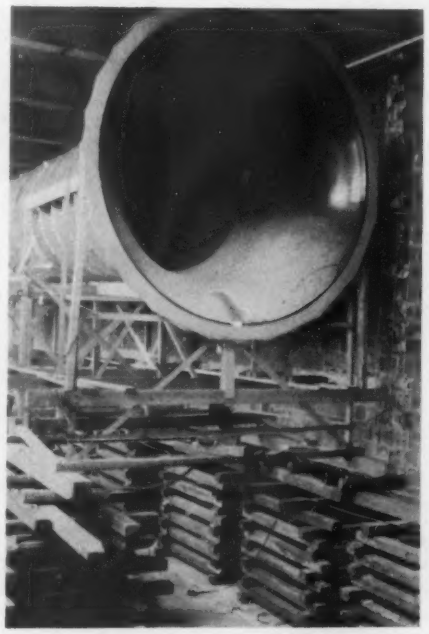
By JOHN R. MARKHAM '18
Research Associate
Department of Aeronautical Engineering
Massachusetts Institute of Technology

ON June 4, the Daniel Guggenheim Aeronautical Laboratory of the Massachusetts Institute of Technology will be dedicated. This building, made available by the generous gift of Mr. Daniel Guggenheim through the Guggenheim Foundation for Aeronautics, is but one of four schools or laboratories established in this country by this Foundation.

It is worth while to note that in each of the universities to be aided by this fund, the wind tunnel research is conducted in a different type of tunnel. This gives to the United States the distinction of being the only country having within its borders all of the known types of wind tunnels.

The laboratory stands on Massachusetts Avenue at the corner farthest from the Charles River, and the architects, Coolidge and Curlson, have given us a beautiful and imposing building, in keeping with the style of the main group.

The building is of steel frame and concrete slab construction. The rear wall is yellow brick, and the front Indiana limestone. The building sits back a considerable distance from the street so that sufficient land is available to furnish a suitable foreground with trees and shrubs, and hedges bordering the walks to the two entrances.



WIND TUNNEL

The old tunnel, formerly housed in one of the wooden buildings, finds a secure resting-place.

The basement, divided into two large rooms, will contain the two wind tunnels. The 7½-foot tunnel which was formerly in the hangar back of Building 10, was moved to the new building while one end of the building was still open, and occupies the large room at the rear. This room is approximately 140 feet long, 30 feet wide, and 35 feet high. These large dimensions were necessary because the open end type tunnel requires a large and unobstructed area for the return of air to the entrance of the tunnel. The same electrical equipment for driving the propeller will be used, as well as the former weighing and recording apparatus.

A 5-foot tunnel of the same type is to be built in the other room of correspondingly smaller dimensions. This tunnel, of construction similar to the 7½-foot tunnel, will be driven by a 10-foot propeller and a 75 horsepower electric motor, and will have a maximum speed of about 100 m. p. h. New and refined automatic weighing devices have been built and will be installed on a platform above the experimental chamber. Provision will also be made for a spindle type balance below the experimental section.

The motor generator sets for the operation of the wind tunnels, together

with their switchboards, are centrally located in a single room at one end of the basement. At the other end a small room is provided for a shop with suitable tools for use in connection with wind tunnel apparatus.

Due to the high rooms required for the wind tunnels, there is little space available at the level of the entrances. However, the small spaces at both ends of the building provide attractive lobbies, from which stairways rise to the first floor. At the north end of the entrance level, there is a room which will be used for storing wind tunnel models and instruments. At the south end two small rooms make convenient offices for the personnel of the Army and Navy Staff of the Reserve Officers Training Corps Ground School.

The first floor extends only over the small wind tunnel on the front of the building. Here is located the wind tunnel staff with a rather large room for drafting and calculating. Next comes the library and reading room, with the aeronautical museum adjoining. At the end is located a students' locker room for their convenience.

On the second floor, the first floor to occupy the entire area of the building, are the offices of the instructing staff, a large undergraduate drafting room, rigging room, and two small research rooms for the use of special assistants.

The third floor contains a large drafting room for graduate students, a room for aeronautical materials testing, two large classrooms, and research rooms for research work in connection with water and air flow patterns, meteorology, and aviation instruments. The photographic dark room is also located on this floor.

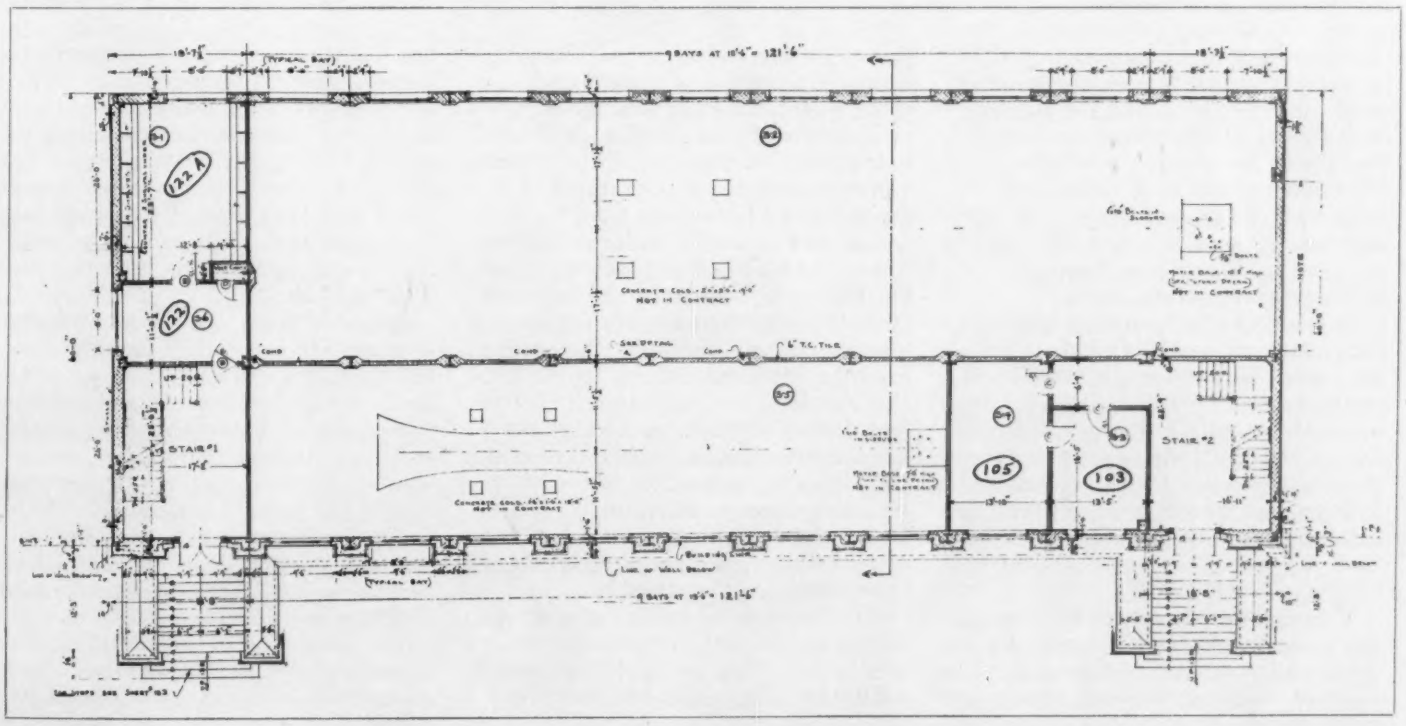
VIEW OF NEW BUILDING FROM LOWER MASSACHUSETTS AVENUE

End of building is left bare to allow for future building program.

All research rooms and laboratories have water, gas and electrical service of alternating and direct current of different voltages. The rigging room has sufficient area and height to accommodate two airplanes of about 35 foot span. Provision is also made in this room for support of airplane structures for sand load tests. The materials testing laboratory is to be equipped with a small Reihle Universal testing machine of about 50,000 pounds capacity, as well as a new type of rib testing machine. On the roof is to be built a large platform for instruction in the operation and use of airplane navigation instruments.

The heat and power connections for the building are brought in from the main supply tunnel through a new tunnel entering the basement at the rear of the building. In each laboratory classroom and drafting room the heating system, in addition to the ordinary steam radiators, includes one or more automatic ventilators in which fresh air, drawn directly from the outside, is passed over steam coils with copper fins. This method of ventilating eliminates many of the large ventilating ducts and large blowers that would otherwise be necessary in a building of this size.

With the exception of the Aeronautical Engine Laboratory, the new building centralizes all the activities and instruction in the course in aeronautics, and is a worthy addition to the main group of our distinctive and admired buildings.



PLAN OF THE FIRST OR GROUND FLOOR

The position of one wind tunnel is partially shown. The larger tunnel is in the large room in the rear of the building.

Avigation

The science of aerial navigation

By ALBERT F. HEGENBERGER '17
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AVIGATION is synonymous with air navigation and has been coined by the Instrument Unit, Army Air Corps, as a more suitable word. It is the directing of the aircraft to its destination over a desired path. This path is chosen usually from a standpoint of reaching the destination most quickly, but sometimes the matter of safety in case of mishaps modifies the route.

Problems of Avigation

Some missions depend entirely on proper avigation; other missions are carried out much better if the aircraft is avigated properly. Elapsed time of flight between two points can be shortened by having the airplane travel fewer miles, as well as by having the airplane travel faster. Unless landmarks are constantly in view and these landmarks are along the most direct path to the destination, some form of avigation is used. The problems of avigation fall into three groups: (*a*) choosing the path or course to fly, (*b*) maintaining direction in the air, and (*c*) ascertaining one's geographical position.

Avigation v. Navigation

Sea navigation and air avigation have little in common. The vast differences in speed, the big dissimilarity in effects due to wind and the difference in stability of the elements in which the craft moves, all preclude using identical methods of attacking the problem. Every procedure and every instrument used in nautical work is modified by the different requirements and limitations of air work.

In one respect, the sea navigator has the disadvantage that water, unlike air, does not completely cover the earth, so that in laying out his course, the mariner must oftentimes deviate from a straight path because a barrier of land juts across the direct path. The avigator is unhampered and can lay out the most direct route.

Shortest Distance Between Two Points

Whenever a plane is passed through the center of the earth, it cuts a great circle on the surface of the earth. The shortest distance between two points on the earth's surface is along the great circle between those points. For short flights it is usually considered sufficiently accurate to draw a straight line on the map. It must be remembered that maps are not true representations of the earth, and a straight line between two points on the ordinary flying map (on polyconic or sometimes mercator projection) does not designate the shortest path between these two places. For distances over five hundred miles, time will be saved if the great circle path is laid out.

One method of doing this is to make use of a chart on the gnomonic projection. A chart on this projection has the property that a straight line drawn on it will be a portion of a great circle. It is not a simple matter to find directions or distance on this chart, so it is usual to transfer this line point by point onto a mercator chart. For example, if it is desired to fly from New York to Paris, a straight line would be drawn between those two cities on a gnomonic chart. See Figure 2. This is the shortest path, even though when transferred onto a mercator chart (Figure 3) it appears as a curve, seemingly much longer than the rhumb line which is the straight line drawn between the two places on the mercator chart. It should be noted that in flying a great circle course, the direction changes constantly (in practice a change is made every half hour or so), while flying the rhumb line, the true direction is constant.

FIG. 1. SHORTEST DISTANCE BETWEEN TWO POINTS
Demonstrating that the New York to Paris route is along the arc of a great circle.

The shortest distance between two points on the earth's surface is along a great circle. A great circle corresponds with the line made by stretching a string between the two points on a globe (Figure 1). The lines joining the poles (called meridians) run true north and south, and it will be noticed that the great circle crosses each meridian at a different angle. This means that the direction in going from one point to the other is constantly changing.

Determining the Path of Flight

In deciding on the path to be flown, considerations of safety or of convenience in case of forced landing enter in. For example, on a New York to Paris hop, flying via Newfoundland is shorter than following the steamship lanes, but the latter route would afford more hope of rescue in case of engine failure. Over land a route along a railway might be chosen rather than a shorter route across barren uninhabited country which would offer little succor if the airplane is forced down.

Climatology would influence choice of route. Meteorology would affect the time of take-off and deviations from the most direct route.

Not only may storms, fog or other flying hazards be avoided to a large extent by a study of meteorological conditions, but often by going to a different altitude or to the right or left of the direct line favorable winds will be found which will enable the aviator to reach his destination sooner. For example, the ZR-3 (later the Los Angeles), shortly after leaving the Azores, received warning of an intense low pressure area centering near the Bermudas. Instead of continuing westward to bring the craft directly into the storm center, the avigator headed north and then circled westward over Newfoundland, thus not only escaping the gale but picking up a tail wind of 65 m. p. h.

Areas of high and low barometric pressure are constantly moving across the United States from the west to the east. A rapid movement and constant succession of highs and lows implies frequent changes in weather, while a slow movement portends a continuation of the present weather.

The weather (clouds, rain, fog, etc.) depends on the shape of the isobars, and these shapes may be roughly classified into seven classes:

(1) Low or Cyclone; (2) High or Anti-Cyclone; (3) Secondary; (4) V-shape; (5) Wedge; (6) Column; (7) Straight.

The wind direction has a definite relation to the isobaric lines and the position of the nearest low. On a stationary earth, air would move per-

pendicularly across an isobar from the region of high pressure to that of low pressure. Due to the rotation of the earth, in the northern hemisphere all winds turn to the right. The wind velocity depends on the closeness of the isobars, *i.e.*, the pressure gradient.

Weather Maps

While a study of a single daily weather map gives certain information, it is much better to study in conjunction with it the maps of the two days previous. In this way the path of the disturbances can be seen and the probable future positions of the disturbance predicted. While for special reasons disturbances sometimes appear seemingly spontaneously, the highs and lows are usually noted first on the west coast and they follow well defined paths across the United States. Figure 4 shows these paths.

Figure 5 shows the weather and direction of wind that may be expected about a low. Figure 6 gives similar information for a high. The characteristic weather for other forms of isobars can be equally well predicted.

While winds at low altitudes cross the isobars at a slight angle, at about 5,000 feet, they are practically parallel to the isobars. Above 5,000 feet they change direction to become more nearly west wind. The velocity increases with altitude to the height of cirrus clouds (20,000 feet to 30,000 feet). Above this altitude winds decrease in velocity. Roughly, the wind at 5,000 feet has twice the velocity as at the ground.

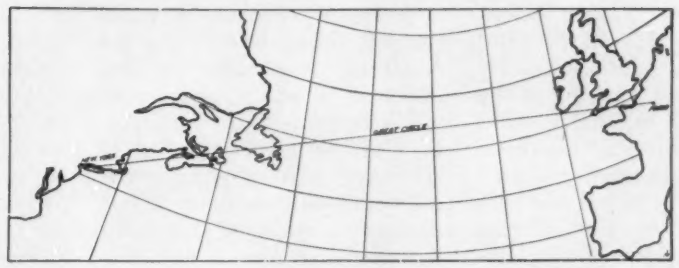


FIG. 2
Gnomic projection. Every straight line drawn on this chart will be a portion of a great circle.

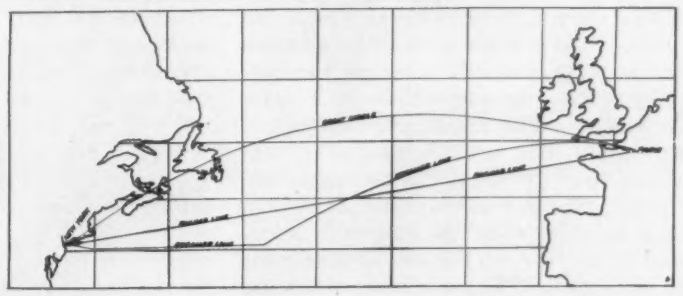


FIG. 3
Mercator projection. The shortest distance between two points on this chart will be a curved line.

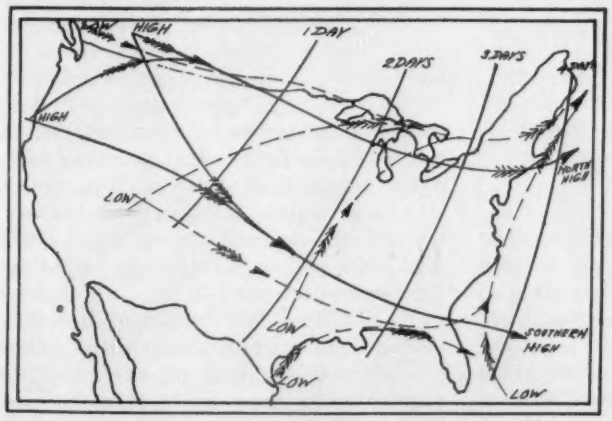


FIG. 4
Showing how areas of high and low barometric pressure travel from west to east along well-defined paths.

For ordinary avigation work, the earth is considered to be a sphere. Maps are representations of the earth's surface, but since it is impossible to represent correctly a spherical surface on a flat surface, no map is correct in all respects.

There are four uses of maps: to find the comparative size of two or more areas, to find the distance between places, to find the shape of physical features, or to find the direction of one place from another. No map gives the correct information for all four uses. A type of map may be proper for one use and not for other uses, or it may be a compromise giving reasonably correct information for two or more uses. Again it may be reasonably accurate in one portion and not in another.

Of the three principal projections, the gnomonic projection is correct about the center of point of tangency but useless near the edges. The mercator projection is good along the equator but distorted in high latitudes. The polyconic projection is good along the central meridian, but distorted away from the central meridian.

It is important that the avigator know wherein his map or chart is distorted so that he may use it intelligently and correctly. Of the four uses mentioned above, the avigator uses a map chiefly to find directions and secondarily to find distances.

The direction obtained from a map is always a true direction, *i.e.*, the angle from the true north. Since a compass is used to maintain direction in the air, it is important to know what the compass should read when the plane is traveling in the desired direction. Every compass is subject to two errors, error of declination and error of deviation.

Compass Errors

The compass needle does not point towards the true or geographic North Pole, but (when unaffected by local magnetism) towards a place in Northern Canada known as the North Magnetic Pole. The difference between the direction of the Magnetic Pole and the true north is known as declination (or variation). The amount of declination and its sign (plus if westerly and minus if easterly), depend on the geographic position of the compass, and is found on maps of that locality.

The compass in an airplane is affected by the iron and steel in the airplane so that it does not usually point to magnetic north but "deviates" from it slightly. The amount of deviation and its sign (plus if westerly and minus if easterly), depend on the direction theairplane is headed. The amount each compass is affected by nearby iron and steel is reduced to a minimum by compensation, and the remaining deviation is marked for each heading on a card near the compass.

Compass error is the algebraic sum of the declination and deviation errors. In using a compass, allowance must always be made for this error.

The Induction Compass

The Army Air Corps in the past few years has developed a type of compass known as the Induction Compass. This compass is of the distant reading type, that is, the sensitive or direction finding element is placed at a remote point in the airplane; there is little or no distortion of the earth's magnetic lines while the indications are shown in front of the pilot. The instrument consists of three major units, the generator, the controller and the indicator. The controller, which is calibrated in degrees is connected to the generator by a flexible shaft, while the indicator is in the electric circuit of the generator. As mentioned, the generator is the direction responsive element of the induction compass. It employs the same principle as any electric generator except that the earth's magnetic field is used in place of an induced field. Its output is direct current, and it is therefore provided with commutator and a

pair of brushes. The armature is supported on gimbals so that it will tend to remain vertical and undisturbed by the ordinary rolling and pitching of the airplane. It is driven by means of a small windmill and through a universal joint. A sensitive galvanometer is used for the indicator. The brushes are rotated about a normally vertical axis by the controller, the dial of the controller showing the angle at which the brushes have been turned in relation to the fore and aft axes of the airplane. Electric current is, of course, generated in the armature, rotating so as to cut the earth's magnetic flux. When the brushes of the generator are in the plane of the magnetic meridian, that is, when they are magnetic north and south, the output of the generator is maximum. That is, the brushes are commutating from the conductors of the armature that are cutting the earth's magnetic lines at right angles. Likewise the generator output is a minimum when the brushes are east and west, because the commutations are being made on the conductors moving tangent to the earth's lines of force.

For example, when the air plane is heading east the brushes of the generator will be turned to the fore and aft axes of the airplane, or in an east and west direction with the controller set on 90 degrees. With the brushes in this position there is no electricity being generated and the indicator will show zero. Now if the airplane is moving on to a new heading, the brushes of the generator will be no longer east and west and the electric current will be generated which will show on the indicator. To restore the airplane to its course will require that the pilot apply his rudder until the needle again returns to zero, which would mean that the brushes would again be returned to magnetic east and west. Assuming it is desired to change the course to 115 degrees, the controller is turned until the dial indicates 115 degrees. Turning the controller revolves the brushes, and the generator begins to produce electric current which registers on the indicator, and will continue to do so until the airplane's heading is changed and the brushes are again in an east and west direction.

Drift is usually a matter of slight importance to steamships, but it is of primary importance to aircraft.

A steamer floats in water and is usually about two-thirds submerged. A strong cross wind blowing against the part of the steamer above water will have little effect against the resistance of the lower structure to moving sideways through the water. Even a twenty-mile-an-hour wind blowing against an ordinary ship will not move it more than one or two miles to leeward in an hour. By observing the wake or the direction the log line streams astern, this drift can be easily and accurately estimated.

With airplanes, conditions are different. They are buoyed up and fly in a mass of air. If this mass of air moves bodily in some direction, the airplane, which is floating in this mass of air, is carried with it. So if an airplane is flying in a mass of air which is moving twenty miles an hour in a direction at right angles to its course, every hour that the airplane flies forward it is carried twenty miles sideways.

A man walking about in a railroad car, or a fly in flight in the same enclosed space, is traveling over the ground, a motion which is the combined result of his own motion and the train's motion. If the curtains are drawn so the man cannot see the countryside through which the train is passing, the man can have no true conception of the rate at which he is traveling.

Instruments have been developed which tell accurately the rate at which an airplane is traveling through the air. Unless the aviator can see the ground or he is reliably informed as to the wind's speed and direction in the locality and at the altitude where he is flying, he can have only the vaguest idea as to his true direction and speed over the ground.

Over land it is possible to measure drift by sighting on objects on the ground. If they appear to be traveling directly backwards to the observer on the plane, there is no drift. If the objects appear to travel to one side as they pass rearwards there is drift.

Over water, where there is scarcely any object on which to sight it is customary to use smoke bombs. These are ignited and dropped overboard. It is assumed that a bomb will drop directly down. Shortly after striking the water it begins to give off a dense smoke so that it can be seen quite a distance. After the airplane has travelled a couple of miles the observer looks astern over the tail of the airplane. If the smoke is seen directly in line with the vertical fin, the avigator knows he has been flying straight ahead. If the smoke is seen off to one side, the observer knows he has been drifting.

Lines are painted on the horizontal part of the airplane's tail. These lines radiate from the point in the rear cockpit where the observer's eye will be. By means of these lines in sighting on the smoke bomb it is possible to estimate drift to within one degree accuracy. At night, bombs are used which give off a bright light instead of smoke.

On the author's Hawaiian flight smoke bombs did not prove effective due to the smoke being laid down in the troughs of the high seas by the strong winds. A close study of the complex and ever-changing pattern of the rough sea below disclosed that part of the spume flecked off the tops of the breaking waves remained stationary behind the onrushing waves. Drift was obtained accurately by sighting on these patches of foam.

Even though the speed and direction of the wind is known at point of take-off, after flying a short distance the wind may be expected to change. This will cause the drift to change so that the initial heading of the airplane will no longer be correct for following the desired path over the ground. It is, therefore, essential to know the effect of the wind. The angle of drift may be measured, if the ground is visible, by means of bearing plates or drift indicators. The ground speed can be measured by timing the passage of an object on the ground between two cross hairs in the drift indicator, provided the actual height of the airplane above the ground object is known.

(*Continued on page 162*)

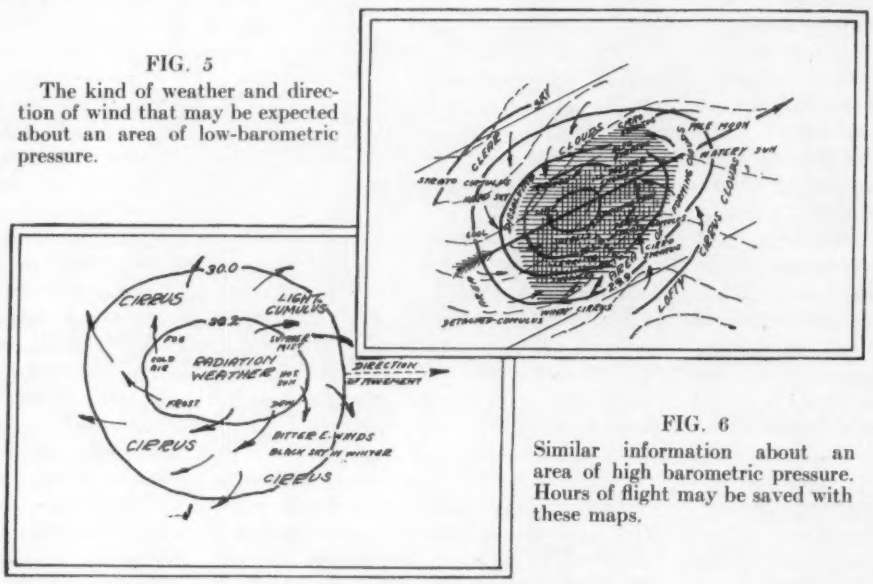


FIG. 5

The kind of weather and direction of wind that may be expected about an area of low-barometric pressure.

FIG. 6

Similar information about an area of high barometric pressure. Hours of flight may be saved with these maps.

Intercommunication Between Aircraft, and Between Aircraft and the Ground

A review of some of the possible methods of aerial communication exclusive of radio telephony and telegraphy

By SAMUEL NIEDELMAN '28

WHEN, in the days of Nero, Simon the Magician boastfully announced that he could communicate with the birds, the stars, and "flying things," he was looked upon with the greatest suspicion and mistrust. To prove his superior powers, he offered even to rise up into the air, and, disappearing in the heavens, write in flaming letters upon the clouds, messages received from the celestial bodies. The populace, taking him at his word, assembled to witness the remarkable feat. Simon did rise into the air, but, Peter the Apostle recognizing him as being in league with the evil spirits, prayed him down with such ardor that poor Simon fell to earth and suffered a broken neck.

Ever since then conniving with the demons has become distinctly unpopular, and the unhappy scientist has had to deprive himself of the pleasures of performing "feats of magic." Indeed, he has even been obliged to explain his secrets in woefully simple terms for fear of being accused of downright wizardry.

Where Simon failed with his magic, we shall, herein, show how others have succeeded and may succeed, if not in communicating with the birds and stars, at least in transmitting intelligence back and forth from "flying things" to the ground and even between the creatures in full flight. In no case are the wicked devices of the nefarious arts resorted to. Take for example the procedure so totally lacking in subtlety as shouting from the air, "Hey there, where are we?" to be answered, after hovering above the questioned ones, by large characters written upon the ground, "Dover." It is so simple as to be almost lacking in dignity. Even such garnishing as calling it a combination of acoustic and visual signaling will not improve it, for it depends for its effectiveness upon the ability of the enquirer to raise his voice above the drone of the motors in the air and upon the availability of paint on the ground. Except in the case of slow-moving aircraft such as balloons and dirigibles flying at low altitudes with the motors throttled down so that a megaphone may be used, this scheme has a rather limited application.

Then we have the electric horn, commonly associated with earth-bound vehicles. The horn, tuned so that it is easily distinguishable above the noise of the exhaust gases expanding violently into the atmosphere, may be sounded in long or short blasts with the aid of an electric button according to some standard code, or simply to notify the recipient of some prearranged meaning. Military authorities have found that this method serves admirably, under favorable conditions, for interplane communication as well as for the interchange of intelligence between aircraft and the ground. Too much confidence should not, however, be placed in acoustic signals. One has but to refer to the elaborate experiments made by the English Government under the eminent scientist Professor Tyndall, and to the long series of experiments made by Prof. Joseph Henry of the Smithsonian Institute, for the United States Lighthouse Board, to ascertain the fact that it is impossible to produce a sound signal in the atmosphere that will be audible in all conditions of weather at a distance o even one hundred feet. The most powerful steam siren that can often be heard at a distance of fifteen miles, will frequently be inaudible at the distance of a ship's length. Because of the varying conditions of the atmosphere as to density, temperature and motion, which tend to break up, reflect, and refract the sound waves, signals sometimes mislead the observer and are often entirely inaudible. For our purpose, therefore, the electric horn and even the siren may not be considered as altogether reliable means of transmitting intelligence.

The James Means Memorial Prize was founded in 1925 by Dr. James H. Means '06 in memory of his father, the late James Means, a pioneer in aeronautical investigation and an active contributor to aeronautical literature at the beginning of the present century. The prize is awarded annually for the best essay submitted by an undergraduate at the Institute on an assigned aeronautical subject. The first winner of the prize in 1926 was Mr. Manfred Rauscher '26, now a member of the staff of the aeronautics department. The competition was not held in 1927, so that Mr. Niedelman is the second winner of the prize.

Of the visual methods, there is much to be said. There was the curious case during the war of two deaf-mutes in the German air force who operated together and communicated by means of the one-hand deaf-and-dumb alphabet. During a veritable epidemic of aeroplane stealing by the French from the German lines, a German ace, seeing his brothers in arms gesticulating to each other in the air, mistook them for French pilots. He immediately attacked them and brought down his supposed adversaries before he could realize his mistake. If the penalty for talking with the hands is death, we ought certainly to use discrimination about the way we say things. We shall, therefore, definitely rule out talking with the hands, especially to avoid international complications.

Semaphores, ground panels and discs have all been used for aircraft signaling. When semaphores are used they are mounted in a horizontal plane, usually both on the upper and lower surfaces of the fuselage, so that they may be observed by craft flying overhead or underneath, or by sighting from the ground with a telescope or prismatic binocular. Much confusion is caused by the relative position of the sender and receiver of the message and signals are often mistaken due to sudden manœuvres. Moreover, semaphores are difficult to install properly, and to be effective must be rather large. For this reason, they have not been used to any great extent, either here or abroad.

By the use of discs, the difficulty due to mistaking signals because of position, was largely eliminated. A single set or several sets of discs are so arranged that sectors of varying areas may be exposed, and in this manner a message is sent. The long time necessary to learn any comprehensive code for this arrangement as well as its comparatively short range, soon eliminated this scheme also.

Ground panels have met with much more success, though they can be used only in signaling aircraft from the ground. Successive arrangements of

(*Continued on page 182*)

Topographic Maps from Aerial Photographs

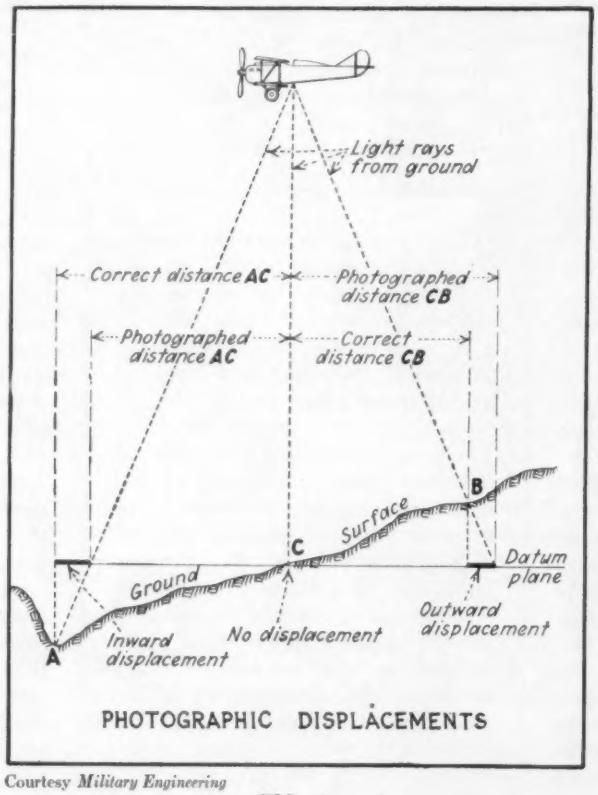
A description of the developments in aerial surveying

By EDWARD S. WOOD, JR.
Cartographer, Brock and Weymouth, Inc.

IN current discussions about the future of aviation the public is prone to draw its conclusions from the success or failure of a few spectacular ventures and overlook the enterprises in which the airplane has already made a firm place for itself. The Post Office Department, the forest fire patrols and the aerial surveyor all find the airplane a satisfactory commercial vehicle with an expanding field of usefulness. This is especially true in aerial surveying, where in the planning of large projects there is an increasing demand for the use of aerial photographs in one form or another. This industry began in 1915 when a company took a series of overlapping photographs at Fort Sill and joined the pictures together to make what is known as a mosaic. From this first step when the pictures were merely tintypes and the service ceiling of the ships obtainable was around four thousand feet, the industry has grown until now the ninety odd companies engaged in this work use the most modern photographic equipment mounted in planes having a service ceiling as high as seventeen thousand feet.

Already aerial photography has a myriad of uses, and new ones are constantly being found. For convenience this work may be divided into two branches: 1. Pictures taken with the lens axis intentionally inclined (obliques). 2. Pictures taken with the lens axis approximately vertical (verticals). In the United States the work in the first class has been mainly confined to taking photographs that have pictorial or news interest, but that are of little value to the engineer. (The pictures taken by the United States Geological Survey with the tri-lens camera are not classified as obliques because the two oblique wing pictures are transformed to the approximate vertical before they are used for mapping purposes.) In Canada, however, obliques have been used to a great extent in small scale mapping in the lake districts. Obliques are suitable for mapping only in this special case where the scale is small and the relief so slight as to be negligible.

So far, most of the work done in the United States falls under branch two, pictures taken with the lens axis approximately vertical. This branch is again divided into two classes: 1. Pictures that are to be used singly or joined together to form a mosaic of photographs. 2. Pictures that are to be used as the source of information from which an accurate contoured map is to be made. In this case the pictures themselves do not appear in the final product. They are merely the means to an end.



Courtesy *Military Engineering*

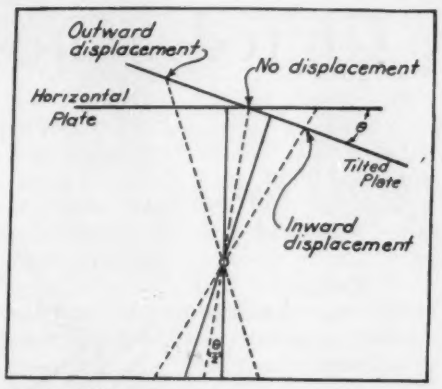
FIG. 1

Photographs are conic projections. Any ground relief causes scale change or point displacement. Accurate mapping must take care of this.

A set of individual pictures covering the territory to be mapped assists the topographer in the work of obtaining detail. Clearings, lakes, roads and houses are all clearly discernible and can be transferred quickly from the photograph to the map. The United States Geological Survey finds that this use of vertical pictures reduces the time required to obtain the detail by at least twenty-five per cent. Furthermore, there is a time saving in the actual field work because the chief of party obtains an intimate knowledge of the country to be mapped and can plan his work to the best advantage.

When a series of pictures is taken in such a way that they overlap somewhat, the photographs may be joined together to form what is known as a mosaic. Mosaics are made with varying degrees of accuracy. In the *uncontrolled* mosaic the pictures are merely joined in such a way as to get a good fit. This may result in considerable errors. To avoid this many mosaics are *controlled* by plotting the positions of several known points that are recognizable on the photographs and making the images occupy their correct positions. This eliminates the gross errors of the uncontrolled mosaic, but there are still possibilities of local error due to imperfect control, fudging of pictures to obtain a good fit, tilt in the pictures, and relief on the ground. If these limitations are fully understood, mosaics may be used for many purposes such as city planning, tax assessment surveys, surveys for the location of transmission lines, traffic studies, and so on.

But if a mosaic, either controlled or uncontrolled, is to be safely used, its limitations must be fully understood. First, a photograph is a perspective projection, and ground elevation change causes a displacement of image points. Figure 1 shows that on the photographic plate point A, below the datum, is displaced inward, and that point B, above the datum, is displaced outward. Also the contour line running through A is farther from the lens than the datum is, and therefore its scale will be too small. The contour through B will be nearer the lens than the datum is, and its scale will be too large. Thus in rolling country the scale of the picture will not be uniform but will vary throughout. A map, on the other hand, has a uniform scale since it is an orthographic projection of the ground. Next it must be remembered that the most improved methods of camera suspension will only keep the lens axis approximately vertical. Figure 2 illustrates the effect of this tilt, which is present in all aerial photographs in varying amounts. The distances on the elevated side of the plate are all too great and those on the depressed side are all too small. Accordingly tilt introduces a further scale variation in the picture. Furthermore, it is not possible to fly an airplane at a constant height, and pictures taken from different elevations have different scales.



Courtesy *Military Engineering*

FIG. 2

Photographic displacement due to camera tilt. Distances on the upper part of the plate are too great, those on the depressed portion too small.

This introduces still a third factor that causes scale variation in the final mosaic. This particular error may be fairly satisfactorily compensated for in the office by enlarging or reducing the pictures, but there is no guarantee that the correct compensation has been attained.

A mosaic with all these sources of error has only a limited application in engineering, but a method known as the Brock Process has been devised to transform the information obtained from the photographs into accurate topographic maps with any desired scale from two hundred feet to the inch to three thousand feet to the inch and contour intervals ranging from one foot to fifty feet. A map made by this process has the advantage over a similar map made by a ground survey in speed, accuracy and economy.

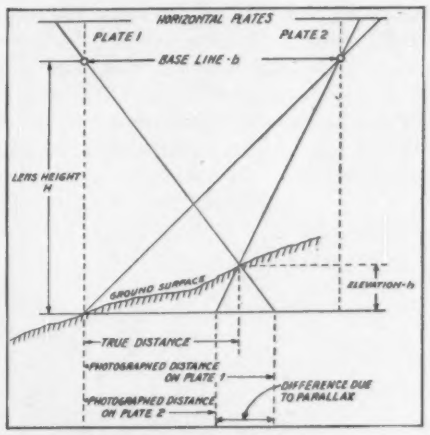
There are several reasons why an aerial topographic map can be made with more speed than is possible by ground methods. Dense undergrowth and steep, rugged mountains are as easily passed over by the airplane as flat, open country. Field parties making a map from a ground survey may be held up for weeks by weather conditions, while if the map is made from aerial photographs, once the pictures are taken and the elevations of a few points determined by the usual survey methods, the work is entirely independent of weather conditions and can proceed both day and night if necessary. An engineer in a construction project in the Southern Appalachians has said that the aerial method did in six months what would have taken eighteen months if the map had been made by a ground survey party.

But this new process not only increases the speed; at the same time it improves the accuracy of the map. In the usual ground survey certain key points are very accurately located, but farther from these control points the work becomes less accurate. When contours are drawn the elevations of a comparatively few points are measured. The contours are then drawn by eye, using the known points as guides. The accuracy of contours drawn by this method depends to a large extent on the skill of the topographer. In an aerial map the accuracy is uniform throughout. Contours are drawn by the virtually mechanical location of an infinite number of points, and the human element is reduced to a minimum. Also the possibility of overlooking detail is greatly diminished, because all natural features stand out clearly.

The results of actual maps made by the Brock Process show that it has the advantage over a ground survey in speed and accuracy. Actual practice also shows that it is possible to do the work more cheaply by the aerial method. In addition to these outstanding advantages there are three other features in which the aerial map is superior to the ground survey. The photographs form a complete permanent record of the work, and any questionable point can be quickly checked in the office without sending a party into the field. This permanent record also makes it possible to add information to the map if at any future time it becomes desirable. After the map of one hydroelectric project was practically completed it was decided to raise the top contour fifteen feet. This was quickly and easily done by the Brock Process, since it involved no extra field work. The plates were merely put on the stereoscopes and the contours added.

Very often secrecy is important, and the aerial method is ideally suited to projects where this is essential. The fact that the base from which the plane operates is usually many miles from the project, added to the fact that a very small ground party is used, makes it possible to maintain secrecy much longer than if the map were made by the usual ground methods.

The various advantages that the Brock Process offers are due to the fact that very precise optical apparatus is used throughout and that research has developed ways of transforming the perspective projection of the photograph into an orthographic projection. Since the aerial camera makes the fundamental record from which all information is obtained, every precaution must be taken to ensure its accuracy. The lens must be absolutely free from distortion and must be mounted with its axis absolutely perpendicular to the focal plane of the camera. Since many measurements are made to the thousandth of an inch, it has been found impossible to use film because of its irregular shrinkage. Glass plates, carefully selected for flatness, are used entirely in this work. The camera is made mainly of aluminum and its alloys, and is supported in a gimbal mount. The center of gravity is well below the point of suspension, and accordingly the weight of the camera tends to keep the lens axis vertical. In spite of this, small tilts invariably occur and these must be removed by a suitable reprojection before the pictures can be utilized for mapping work.



Courtesy *Military Engineering*

FIG. 3

Showing parallax due to change in ground elevation.

CAMERA MOUNTED IN AIRPLANE

Even with the latest improvements, it is possible to obtain only an approximately vertical axis all the time.

In order to understand how this correction is accomplished a little fuller description of the effect of ground relief will

(*Continued on page 182*)

The Experimental Mine of the United States Bureau of Mines

A résumé of the equipment and methods used by the Bureau in mine explosion research[1]

By H. P. GREENWALD
Supervising Engineer
Experimental Mine Section
United States Bureau of Mines

THE United States, through the Department of Commerce and Bureau of Mines, possesses the only coal mine in the world developed and maintained solely for experiments to promote safety and efficiency in the mining industry. The original purpose of the mine was to determine the causes and the methods of preventing dust explosions in coal mines. The first recorded explosion in a bituminous coal mine in the United States occurred in 1839, when 40 men were killed in a mine near Richmond, Virginia. The Pocahontas explosion in 1884 was the first disaster to claim more than 100 lives. Explosions continued to increase in number as the size, depth, and number of mines in the country increased. In 1907, 865 men were killed in eleven explosions in bituminous coal mines, and three of these claimed 656 lives in less than two weeks in December. Attention was focused on the matter and Congress appropriated money for an investigation which was started by the Technologic Branch of the United States Geological Survey in July, 1908. Two years later the Bureau of Mines was organized and the work transferred to it.

FIG. 1. ENTRANCES TO THE EXPERIMENTAL MINE
The pit mouth is shown on the right. Boiler house, grinding house, service shops, observatory and other buildings appear on the left.

[1] Published with the approval of the Director, United States Bureau of Mines.

Those in charge[2] after study at home and abroad thought that experiments would have to be conducted on a large scale in an actual mine to carry conviction to the industry. Investigation showed that a suitable abandoned mine could not be obtained and search was then made for a suitable location for a new mine. An area in the Pittsburgh coal bed, free of fire damp and having natural gas available for experiments, was desired. It had to be at a safe distance from dwellings and yet near Pittsburgh, Pennsylvania, where other work of the bureau was conducted. Other factors, such as drainage and water supply, railroad and highway connections, and surrounding hills to break up pressure waves from explosion, influenced the decision. The present location near Bruceton, Pennsylvania, thirteen miles from Pittsburgh, was selected as the best obtainable, and work was started early in the winter of 1910. Nearly a year elapsed before enough entry was driven to permit a public experiment and demonstration.

[2] The late Dr. Joseph A. Holmes, first Director of the Bureau of Mines, and George S. Rice, chief mining engineer.

First Public Demonstration

In October, 1911, two main entries had been advanced 725 feet into the hillside; a third entry, driven on a slant near the crop line, connected one of the main entries with the fan. It was felt necessary to prove that coal dust in air was explosive in the absence of fire damp (methane) a matter stoutly denied by many people. A public demonstration to prove this was arranged for October 30, 1911. In this demonstration fine coal dust was distributed throughout the mine and blow-out shots of black blasting powder were fired into it. Approximately 1,500 visitors were present and more than 1,000 of them went through the mine before the test. When all were in safe positions and the electric circuits were closed to fire the shots no explosion resulted. The shot-firing wires had been trampled and short-circuited during the explosion and installation of a new line was necessary. A drizzling rain was falling and it was dark when the shots were finally fired. The resultant explosion burst from every opening in the mine with a concussion that was heard and felt for miles, and the immediate countryside was lighted by the huge volumes of flame that reached points 500 feet from the mine mouth. It was felt that the explosibility of coal dust needed no further proof, and efforts were concentrated on determining the conditions under which explosions occurred and the best methods of preventing them.

The Experimental Mine Today

The experimental mine has grown steadily in size and equipment since the first test was made. Figure 1 gives a view of the surface features with the pit mouths on the right. The principal buildings are grouped at the left and include substation, boiler house (for heat only), grinding house for preparation of coal dust and rock dust, miners' wash and change house, service shops, storage, clubhouse and office and observatory. The fan and fan house are at the left center of the picture. The building housing the office and observatory is farthest up the hill at the left. The observatory contains the

instruments used in recording the phenomena of explosions.

The underground workings are shown in Figure 2. The coal is about five feet thick; the bed is level and outcrops along the hillside. The mine is opened by drift entries 1,300 feet long, known as main or face entries. A single entry 100 feet long and some minor workings have been driven to the right and a pair of side or butt entries with eight rooms opened on the left. The innermost cut-through connecting the two main entries is open; all others are closed with explosion-proof stoppings. The inner 350 feet of these entries is the section in which most of the test work has been done and is commonly known as the standard test zone.

Reinforced concrete chambers have been placed in the rib at 200-foot intervals to house such of the recording mechanisms as must be in contact with the explosion. Two electrical cables, one carrying 31 wires for instrument control and record and the other carrying four wires for power, connect these instrument chambers and the observatory.

The physical phenomena measured in every explosion are the speed of flame, the pressure produced, the direction of movement of the air and gases, and the extent of the flame. All save the last of these require measurement of time. Special measurements, such as the time of operation of rock-dust barriers, are made as required. An extended study has been made of the composition of the atmosphere immediately before, during and after an explosion. Attempts to measure the temperature of the flame and the velocity of the air and gases distinct from that of the flame have been only partly successful.

All time measurements are made on two chronographs installed in the observatory. The normal duration of flame in an experimental mine explosion test is 1.5 to 3.0 seconds, consequently absolute accuracy of 0.005 second is necessary and of 0.001 second is desirable. The chronograph drums have a peripheral speed of about twenty inches per second. Time is given in hundredths of seconds by a tuning fork and readings to 0.001 second are estimated, although the accuracy is probably not as great as this. Each wire in the cable from the mine is connected to a separate pen, as in a great majority of cases the sequence of events cannot be foretold. Zero time is taken as the instant of initiation of the explosion and is obtained through the mechanical rupture of a fine wire by the igniting source. Flame velocity is determined by recording the time of fusion of tinfoil strips placed at 100-foot intervals along the passageways. This method has been found best, although it introduces an unavoidable lag of fusion.

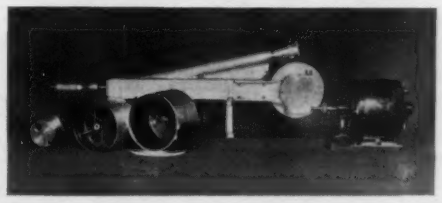


FIG. 3
BUREAU OF MINES MANOMETER
This instrument records pressure continuously during the explosion.

Pressure is recorded continuously during an explosion by Bureau of Mines manometers in the instrument chambers. The Bureau of Mines manometer is of the diaphragm type, the diaphragm movement being magnified by an optical lever and recorded on a moving photographic film. A photograph of the instrument is shown in Figure 3. The diaphragm is in the brass head at the left and is connected by a pin to a pivoted concave mirror. A beam of light obtained from an automobile headlight bulb in the shroud immediately above the film box passes through a pinhole and is reflected by the mirror to film which is wound on a drum rotated by the motor. The time of revolution is determined by suitable contact devices recording on the chronograph in the observatory. The manometer is also arranged to photograph any flame that passes it. A tube conducts the light to a focusing lens and the record is obtained along one edge of the film.

The direction of movement of air and gas during an explosion is indicated by a device consisting of a small vane fastened to a shaft which can rotate through an angle of 60° in either direction from a central position in which it is normally held by a torsional spring. Movement from the central position completes an electric circuit and gives a record on the chronograph. The vane is the only part of the instrument exposed to the explosion.

The manometer and the tinfoil and air-direction indicator are in instrument stations with only the necessary parts exposed through a steel plate. The manometer connection plug has two openings; one is for admission of pressure while the other is for admission of light.

The air and gases are sampled automatically during explosion tests. The sampler consists of an evacuated cylindrical brass tube closed at one end by a needle valve and at the other by a thin glass plate. The tube makes a slip fit in a frame at whose front end a head having steel breaker prongs backed by a rubber stopper is screwed. A strong spring clamped to the tube tends to pull the glass plate against the prongs, but the movement is restrained by an operating mechanism at the rear controlled by an electromagnet. On operation of the magnet the tube is released and moves forward; this breaks the glass and the surrounding atmosphere rushes in and is trapped when the tube is jammed shut against the rubber stopper. The sampling lasts about 0.05 second. The actual time of sampling is known from records on the chronograph. This sampler has been designed so that it can be installed in the mine in a 5-inch pipe with only the head exposed. Pipes may be placed at any angle and may extend any distance

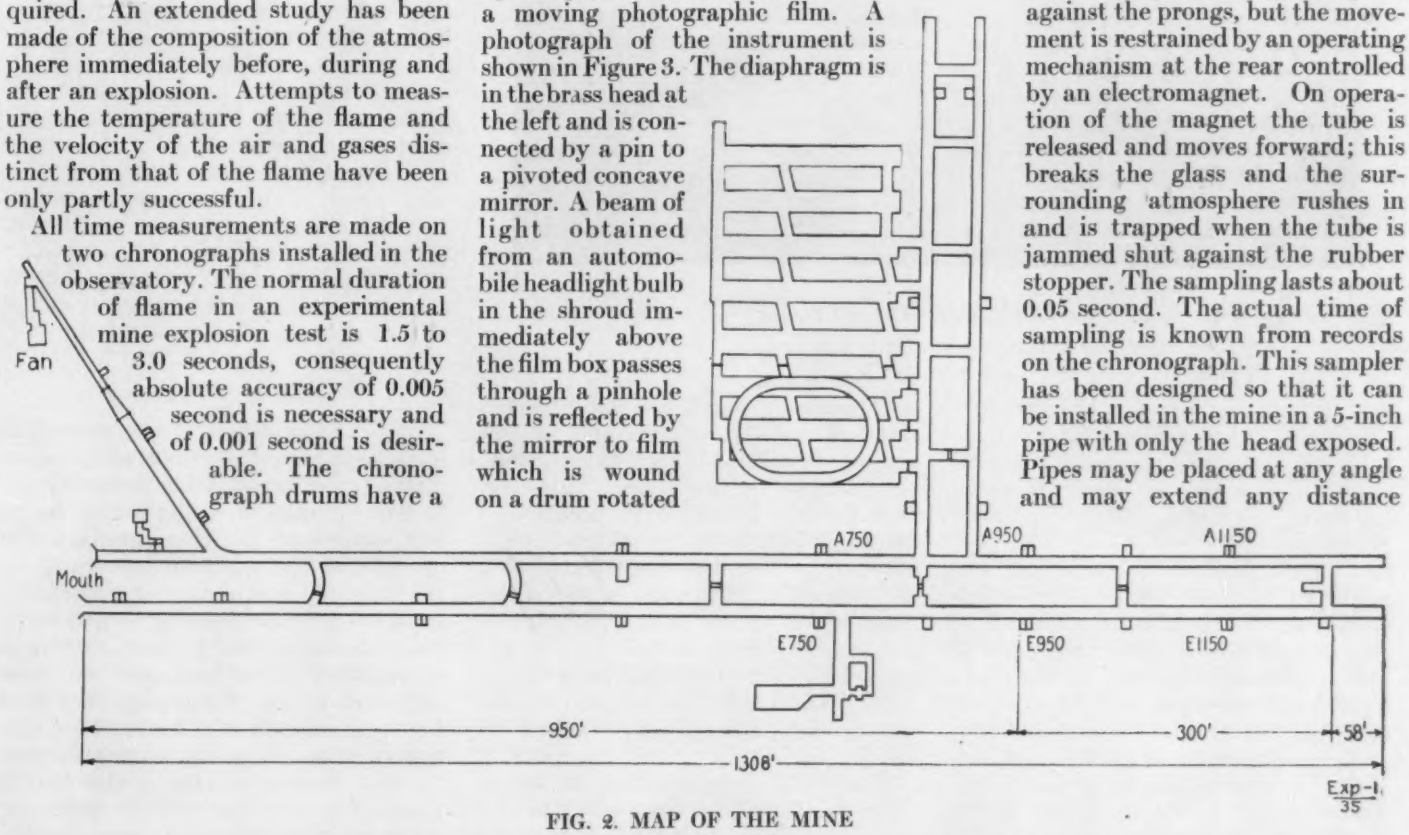


FIG. 2. MAP OF THE MINE

The position of the entries, reinforced concrete chambers and ventilation shafts is clearly shown.

from the rib that is mechanically safe. The samplers may be used singly, in duplicate, or in sequence during an explosion.

The extent of the flame during an explosion is determined by its effect on small circlets of bromide paper fastened in brass containers placed near the roof at 25-foot intervals along the passageways. The bromide circlet is exposed through the openings of a brass stencil and when developed shows a number which identifies its position. The last man who leaves the mine prior to an explosion carries a safe light and removes the rubber plugs from the recorders. After the explosion he re-enters the mine and replaces the plugs before any white light is brought near the recorders.

When the results of an explosion test are to be studied carefully, all records are plotted on a single sheet of 20-inch graph paper. Time is plotted along the X axis, distance along the Y axis, and pressure along the Z axis; manometer curves thus fall in the X-Z plane and are rotated about their zero-pressure line into the X-Y plane.

A bituminous coal-dust explosion is the rapid combustion of the dust suspended in air. Two factors are necessary for an explosion: (1) The dust cloud and (2) the source of ignition. In operating mines the most common origins of dust explosions are fire damp (methane) explosions, improper use of explosives, and electric arcs. The first two have the power to raise dust and ignite it; the last requires a premade dust cloud. Dust explosions started by electric arcs have usually originated at points where moving trips of mine cars have been derailed and have short-circuited trolley wires or power cables.

A gas explosion or a blow-out shot of an explosive causes a concussion which travels as a wave in air and is responsible for the initial raising of the dust. The explosion develops slowly at first, but as the dust burns it creates additional disturbance which either keeps the dust already raised in suspension or raises fresh dust. The flame spreads through the cloud with increasing velocity and violence, and the explosion is limited principally by the extent and composition of the dust on which it must feed.

Flame velocities in explosions vary widely with varying conditions. A velocity of 100 feet per second is about the minimum of a self-supporting explosion; if the velocity drops much below this the explosion dies out. The maximum velocity that can be obtained is not known. In moderately strong explosions flame velocities of 1,000 feet per second are common. In violent explosions the velocities range from about 2,000 to 5,000 feet per second. As the velocities increase they become difficult to measure because the time interval for a given distance becomes very short. While very high velocities have been indicated in certain experimental-mine tests, velocities in excess of 3,000 feet per second have been considered as subject to large error.

Pressures correspond in a rough way to flame velocities. Weak explosions will in general have low flame velocities and light pressures, and violent explosions will have high flame velocities and strong pressures. However, high flame velocities have been found accompanied by low to moderate pressures. The lowest pressure found with self-sustaining explosions is one to two pounds per square inch. The highest pressure recorded is 127 pounds per square inch, although higher pressures have undoubtedly been obtained and manometers have been wrecked by them.

The zone of combustion in an explosion is the center from which heated gases are forced in both directions along the entry. Although the velocity of these gases has not been measured, it must be high to move objects weighing hundreds of pounds, as it has frequently done. The movement of an object during an explosion cannot be traced exactly even if its positions before and after an explosion are known, as it may be driven ahead of an explosion for a distance until overtaken and passed, after which it will be driven back toward the point from which it came.

The gas samples taken during explosions show that combustion is always more complete near the center of the entry than at the ribs, which probably remain relatively cool. Combustion is also more complete in a violent explosion than a weak one. In a violent explosion less than ½ per cent of the oxygen remains unburned and 10 to 14 per cent of carbon dioxide is found. Carbon monoxide ranges from 1 to 4 per cent, and in exceptional cases it has been as high as 9 per cent. Distillation of the hot dust liberates methane, ethane, hydrogen and sometimes ethylene. If any moisture is present the water-gas reaction evidently takes place. Even the weakest explosion will produce an atmosphere that is fatal to life, as the amount of oxygen is reduced to about 5 per cent and there is from 0.1 to 0.5 per cent of carbon monoxide.

The outside manifestations of an explosion are spectacular and impressive. First comes the concussion of the shot or gas explosion, which is used to ignite the coal dust. This is closely followed by a rush of dust increasing in velocity, and a violent explosion ends with a heavy concussion and possibly the ejection of flame from the pit mouth. Figure 4 is a photograph of this phase of a strong explosion. Then follows a long inrush of air to replace that which has been driven out. When ventilation is restored, dense clouds of black smoke are driven from the mine for several minutes, gradually thinning out as the various passageways are cleared.

FIG. 4. EXPERIMENTAL EXPLOSION
Gases issuing from the mouth of the mine.

Prevention of Explosions

Most of the tests in the experimental mine have been made to determine conditions that would either prevent ignition of the dust or extinguish an incipient explosion. Wetting the dust was one of the first methods advocated in the industry as a means of preventing explosions. Experience and experiment have shown, however, that wetting is not reliable. Fine coal dust will float on water in a perfectly dry condition for long periods of time and can be wet only by vigorous mechanical agitation. Moreover, even if the dust is thoroughly wet the drying action of mine air currents rapidly removes the

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Is Industry Interested in Health Education?

The relation of health training to industrial efficiency

By CLAIR E. TURNER, C. P. H. '17
Associate Professor of Biology and Public Health
Massachusetts Institute of Technology

ENGINEERS have long since learned that many contributions to industry are made through pure science, research and other undertakings which are initiated without any consideration of their effect upon industrial efficiency. Few who read THE TECH ENGINEERING NEWS have heard of the studies in health education which have been carried on in Course VII during the last eight years, and still fewer probably have thought of any possible relationship between this work and the industrial life of the country. It is true that thus far our studies have been undertaken purely in the interests of child health. We have given no consideration to any possible advantages which may accrue to industry as the result of our work. Is there not, however, a relationship between health education in the public school and the future industrial efficiency of America?

How great is the health problem of industry? The manufacturer spends large sums upon the improvement of machinery. What of the physiological efficiency of the men and women who are employed?

Cost of Sickness

Labor statistics show that the average large factory does not have more than ninety per cent of its force on the job any one day in the week. Studies by Dr. B. S. Warren of the United States Public Health Service indicate that "each of the thirty-odd million wage earners in the United States loses an average of nine days a year through sickness." If we assume an average wage of only four dollars a day, the aggregate loss of nine days' absence amounts to more than one billion dollars in wages alone. Medical attention adds another three hundred million dollars, to say nothing of the pain and discomfort involved. The English Industrial Welfare Society estimates that no less than ten million dollars a week are lost to British industry through indifferent health or actual illness.

The cost of training new employees, the cost of idle machinery and the extent to which production is reduced because of the lowered vitality of workers are taxes which sickness levies upon industry. Cheney Brothers Company estimates these losses in their own establishment to amount to sixty dollars per person annually.

When we look for an analysis of the causes of illness we find statements like those from the recent study of the United States Public Health Service indicating that common cold and bronchitis are the chief causes of illness. Four hundred eighteen people out of a thousand suffer from common cold and bronchitis during the year and one hundred forty-three suffer from influenza and grip. Every employer knows that the efficiency of an individual may easily drop thirty per cent on the days when the worker is half sick with a cold or some other malady. The loss is obvious when the person is working on a salary but there is also a loss in the case of piece workers through lowered production, increased overhead and the reduced quality of the product. And let us remember that common cold and tuberculosis, for example, although infections, are avoided by hygienic living and vigorous health with high resistance.

Research studies conducted by the Institute in public schools have demonstrated that the habits of living of the average individual are far below the standard made possible by our present knowledge of hygiene and public health. Information alone improves habits but little. A program of training has been devised which is scientifically and psychologically sound and which has produced a demonstrable improvement in habits, attitudes and health. This program adapts the individual to the complex living conditions of modern industrial life. The possibilities of health education are far-reaching. We are glad to present this article to our readers because your industry may be more interested than it has yet realized in the application of these principles among your personnel and in the development of a sound health education program in the public schools of your community.

Healthy Living

The vigorous and healthy employee is likely to be efficient and contented. The health of the average worker depends upon the sixteen hours outside of industry more than upon the industrial conditions under which he works. The key to health is to be found in nutrition, rest, cleanliness, relaxation, recreation and a contented mind. In other words the avoidance of this lowered state of health and bodily resistance which is conducive to colds, tuberculosis and other diseases is not a problem of medicine and surgery but rather an outcome of the daily practice of hygienic living. What would be the effect upon industry and production if every one would undertake during the next year to keep fit for his job as the athlete in training keeps fit for his?

Field of Health Education

But what is health education and what has it to do with this problem? Health education in the public school is a systematic program for developing the habits, attitudes and knowledge which contribute to the best physical and mental health. It is a program in which many people are interested and to which many groups are contributing. Thanks to the vision of Professor Sedgwick, the Institute was one of the first institutions to undertake research and training in this field.

The research contributions which Technology has made to this new and growing health movement are based upon studies which began immediately after the war. These studies were based upon the following premises:

1. Many of the ailments of man are not subject to control by vaccination or any other process of preventive medicine, nor are they subject to control by the purification of water supplies or any other process of preventive sanitation. They are to be reached, if at all, through preventive hygiene.

2. The habits of living of the American people are far below those made possible by present scientific knowledge. Diet, ventilation, relaxation, exercise and even cleanliness are not yet making their proper contribution to physiological well-being.

3. The urbanization of our people, which has followed the mechanical revolution, demands a biological adaptation. The child of today is likely to have less sunlight, less fresh air, less out-of-door exercise, less rough natural food, more excitement, and more nerve tension than had the child of the past. Science must help the human species to adapt itself to its new environment.

4. Habits affect health. This is shown in the experience of tuberculosis preventoria, military camps, athletic training and nutrition classes.

5. Childhood and youth is the period of habit formation and the school should share with the home the responsibility of training our youth in the practice of those principles of healthful living which science has shown to be essential to the human race and which are all the more important to those

(Continued on page 168)

Development and Research in the Bell System

Excerpts from a recent address describing the activities of this great laboratory

By E. B. CRAFT
Executive Vice-President
Bell Telephone Laboratories

THE major problem in the communication industry is the transmission of intelligence by electrical means, and by far the greater portion of our fundamental laboratory work is applied to that part of the general problem. In an oral communication, whether it be directly through the air, or electrically over wires or through space, the essential elements are the organs of speech at one end and the organs of hearing at the other. It has been necessary in order that we may have the proper picture of the problem, or that we may more comprehensively attack the problem, to study first the characteristics of speech and hearing so as to determine the laws governing their functioning, and then to set up on the basis of these studies, the essentials of the electrical communication problem, because, after all, the telephone is but an auxiliary to these human organs.

There have been during the course of the last fifteen years a number of outstanding developments which have had a profound effect upon the communication industry. A few of them may be mentioned to give an idea of the scope of the activity rather than to give details of the things themselves.

Consider for example the vacuum tube. Prior to 1914 the limit of telephonic communication was measured by the distance between New York and Chicago although Denver had been reached experimentally. In order to accomplish this feat it was necessary to employ conductors approaching the size of a trolley wire, an eight gauge conductor. With the advent of the vacuum tube, the practical development of which was carried on by our laboratories, we came into possession of a tool which, associated with other developments such as filters and balancing networks, has fundamentally changed the character of the entire telephone transmission system. It is now possible, as you all know, to talk from New York to San Francisco or even to England, or in fact, to any place to which wires can be stretched or to which radio can reach.

Through the use of the vacuum tube it has been possible to superimpose on a single pair of wires as many as twenty simultaneous telegraph messages, and as many as four simultaneous telephone messages. All through the plant this device has come into play in a manner which has effected a fundamental change in very many things.

Contrasted with the eight gauge copper wire necessary to talk between New York and Chicago twenty years ago, there is now in service between these cities a telephone cable over which a more effective type of transmission can be obtained with No. 19 gauge conductors. As a result of continued studies over a period of many years, it is now possible to place in a single lead sheath two and one-half inches in diameter as many as eighteen hundred separately insulated metallic circuits. It was but a short time ago, comparatively speaking, when the limit was one hundred fifty. This has happened as a result of continued effort toward the improvement of methods and constructing materials.

We hear a great deal about radio these days. It is very much in the public eye, but I imagine few people appreciate the fact that the fundamental principles which have been developed in connection with telephony form the basis for present day radio system. It would be impossible to do what is being done with radio had not this fundamental work in research and development been carried on all these years in connection with the wire telephone art.

A development which will give a picture of a slightly different type of work, is the transmission of pictures

VACUUM TUBES AND CABLE DEVELOPED IN THE BELL TELEPHONE LABORATORIES

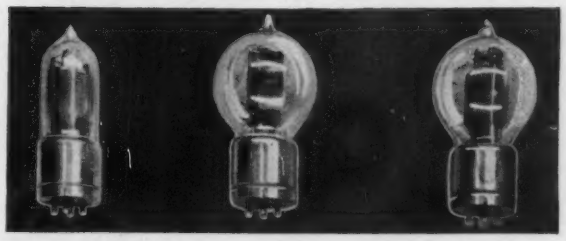
(Above) Section of a telephone cable containing 2424 wires, No. 24 B&S Ga. One-quarter actual size.

(Below) (From left to right) 10,000 watt tube used in successful transatlantic radio telephone tests. 250, 50, and 5-watt transmission tubes for radio. Two rectifier tubes used in changing alternating current to direct current. Ionization Manometer tube for measuring the pressure of gases. Cathode ray ocillograph tube for laboratory research, recording all frequencies up to millions per second. Vacuum tube research is one of the outstanding activities of the Laboratories.

over wires. This is a combination of electrical transmission, photography, and mechanics. Some idea of the mechanical problem involved may be gained when it is realized that the moving mechanisms at the receiving and transmitting ends must be in absolute synchronism, no matter how far apart they may be. The sending instrument in New York must rotate at exactly the same speed as the receiving instrument in San Francisco, and this is no small mechanical problem.

The photographic part of the development seems quite far afield from the communication, but has had to be attacked and solved in order to successfully produce these results. A more recent, but closely allied development, is that of television, first demonstrated less than a year ago. Here the sending time is enormously speeded up to obtain the eighteen pictures per second necessary to represent a moving scene. The time required to send a still picture is about seven minutes. This necessity for speeding up very greatly complicates all phases of the problem but especially those of transmission and synchronization.

Another example in a quite different field is that relating to ocean telegraph cables. Several recent developments in this connection are of considerable importance. Cables have recently been laid by the Western Union Telegraph Company from New York to the Azores connecting with Germany, and to Newfoundland connecting with England. These cables, from general appearance, are no different from the cables that have gone before, but messages can be transmitted over them at approximately five times the speed of cables heretofore employed with approximately the same size of conductor. This has been accomplished through the development of a system of so-called loading, by which the electrical characteristics of a long conductor are better adjusted to transmit intermittent electrical signals. Loading of land lines is old, but loading of long ocean cables is new. It is impossible to space loading coils along the length of an ocean cable a mile or more below the surface of the water, and until



RADIO RECEIVING TUBES

there had been developed a magnetic material possessing properties far superior to those heretofore used, the problem of loading cables remained unsolved.

The development of permalloy, which is a trade name we gave to a new alloy of iron and nickel, has made it possible to accomplish this result. This material, which is not new in its fundamental composition, is quite new as to the control of the ingredients and the treatment of the material in the process of manufacture. It possesses magnetic properties which are truly remarkable. Ordinary Norway iron is probably the best magnetic material heretofore known. Under certain conditions this new material has a permeability of more than one hundred times that of the best Norway iron. It is so sensitive to magnetizing influences that it is saturated by the earth's magnetic field and a given length will measure one dimension when pointed north and south, and another when pointed east and west.

Recently, in powdered form, it has been used for the cores of loading coils for land telephone lines. Its very low magnetic losses have made smaller coils possible which have resulted in considerable savings in cost.

This is a product of research, a combination of metallurgy, electrical engineering, physics, and mechanical engineering. It is another illustration of the kind of work we have to do with fundamental research as its foundation.

There is another type of work of a slightly different character but of tremendous importance to the Bell System relating to the development of the switching and signaling systems which are necessary to interconnect telephones throughout the country. Our problem here is mechanical as well as electrical. It is true we are dealing with electrical signals and we are setting up channels over which electrical circuits may be operated, but the fundamental, primary problem is that of mechanically as well as electrically associating groups of wires, one with another in the best possible manner.

THE ELECTRICAL STETHOSCOPE

This instrument has made it possible to record heart sounds on phonograph records where they are permanently available for the use of students or physicians.

We have also the problems involved in the design and manufacture of telephone apparatus. The tremendous quantities of apparatus which are employed in the system require methods of manufacture which probably are not met with in any other industry. Quantity manufacture is essential. The manufacture of apparatus in quantities with interchangeable parts, is quite a different problem from that of manufacturing in ordinary quantities, where the necessity for interchangeable parts is not so apparent. Because of the large numbers of units which are employed, the attention given to the economy of design and manufacture is perhaps out of proportion to that in other fields.

It should be brought out here that the actual development and working out of the manufacturing processes and methods is a function of the manufacturing organization of the Western Electric Company. The laboratories, except in rare cases, do not devote themselves to the development of the manufacturing methods which

(*Continued on page 174*)

Color in Industry

A description of a new device permitting accurate color comparisons

By ARTHUR C. HARDY
Assistant Professor of Optics and Photography
Massachusetts Institute of Technology

THE color of a substance is one of its physical properties. Strangely enough, although elaborate and precise instruments have been devised for the measurement of many of the other physical properties which a substance may possess, color measurements have always been notoriously difficult and inaccurate. This situation has resulted, not because of lack of interest or effort in this field, but rather from the fact that light, like sound, has associated with it so little energy.

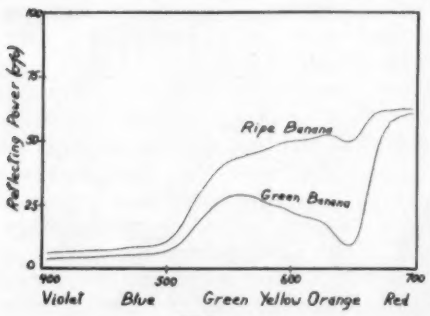


FIG. 1

A typical color analysis or spectrophotometric curve. Note the absorption in the yellow and orange which almost disappears when the banana is ripe.

Any physical instrument with sufficient sensitivity to be actuated by the small amount of energy ordinarily available in color determinations would be altogether too delicate to use. Since photoelectric cells are now available, this situation may be avoided by converting the light energy into electrical energy and then amplifying the latter to any desired extent by means of vacuum tube amplifiers. In this way, the final power output may be made sufficient to operate almost any sort of mechanical or electrical contrivance. However, before describing the apparatus required for color measurements, let us consider briefly a few of the industries in which these measurements are important.

It is obvious at once that color is of extreme importance to the manufacturer and to the user of dyestuffs, since the only possible purpose in dyeing a material is to change its color. This is not so true of paints, varnishes, or lacquers, which serve also to protect the surface, although in most cases color is still their most important characteristic. It is not at once obvious that color measurements should be of vital importance in many other industries, but, curiously enough, there is scarcely an industry without a color problem. In fact, there are many notable examples where color has been elevated to first place in importance when there would seem to be no need for any consideration of the subject at all. For example, lubricating oils are graded almost entirely on the basis of color, although no test has yet been devised to demonstrate that the color of an oil is connected in any way with its lubricating qualities. In the same way, small differences in color mean thousands of dollars in the sales of cottonseed oil. It is an established custom on the New York Produce Exchange for the buyer to demand an oil of amber hue. An oil which is slightly red sells for several cents per gallon less than the "prime" oil, although the difference in color may be so small that it would scarcely be noticed by the ordinary purchaser.

Most of the articles used in every day life lie between the two extremes represented above. That is, the color of the product is ordinarily neither the most important nor the least important property. It is simply one of the properties which many manufacturers attempt to control in order to please either the retailer or the ultimate consumer. For example, a concern whose chief product is canned peaches is under no legal nor moral obligation to maintain a color standard for this commodity. Of course, from the standpoint of the consumer, it is desirable that the peaches from one can should have the same color as those from another, since the contents of two cans may sometimes be placed in the same dish. The more enterprising packing companies, therefore, cater to an exacting clientele by establishing and maintaining a definite set of color standards. In other words, uniformity of color is one of the characteristics of the better grades of merchandise. The desirability of a product of uniform color applies equally well in manufacture of such things as soap, lard, flour, butter, oleomargarine, cheese, sugar, syrup, chocolate, glass, automobiles, tile, brick, roofing materials, carpets, rope, hardware, paper, leather, cement, linoleum, textiles, cosmetics, and many others. In fact, this list could be extended almost indefinitely to include practically every commodity handled in the ordinary trade channels.

Many of the industries represented in the above list are capable of further subdivision. For example, paper includes writing paper, newspaper, colored paper for decorative or artistic purposes, crepe paper, wrapping paper, blueprint paper, and safety paper for banks. There are also industries which do not manufacture in the ordinary sense but which have color problems in abundance, the printing industry being a good example. Color printing is being used more and more for advertising purposes and the public as well as the advertiser is becoming more critical of the results. The manufacturers of false hair, or artificial eyes and teeth, have similar problems requiring accuracy in color matching without the benefit of production in quantity. Even educational institutions are concerned with color questions, the Massachusetts Institute of Technology having recently taken steps to standardize the official cardinal and gray so that the Institute colors may hereafter be reproduced exactly and forever.

Color measuring instruments may be divided into two classes — color analyzers and colorimeters. The color analyzer gives information of the sort shown in Fig. 1. These two curves happen to represent the color of a green banana and a ripe banana. The ordinates are reflecting powers referred to magnesium carbonate (the whitest substance known) as a standard, while the abscissae are wave-length values in the

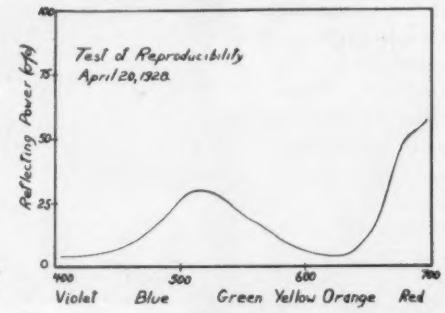


FIG. 3

A test of the reproducibility of the instrument. With the specimen of green silk, two curves were made which are practically superimposed.

spectrum plotted in millionths of a millimeter. A curve of this sort is a complete and permanent specification for a given color.

The color analyzer which furnishes the data from which the curves of the sort shown in Fig. 1 may be plotted is sometimes called a spectrophotometer. These curves are so valuable that it is unfortunate that spectrophotometers should always have been so difficult to

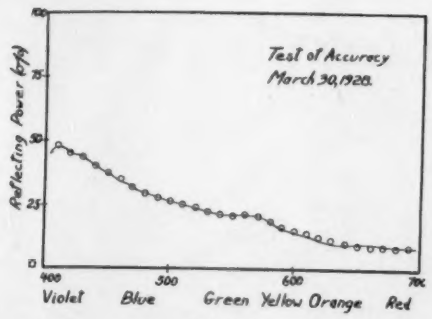


FIG. 4

A test of the accuracy of the instrument. The plotted points represent values obtained at the Bureau of Standards. The specimen in this case was a piece of colored glass.

use. They are difficult to place and maintain in proper adjustment and require the making of a large number of difficult settings to obtain the proper precision. Thus, to measure a single color, it is necessary to make about four settings of the instrument at each wave-length and to make readings at some fifty points through the visible spectrum. From these data, the average setting at each wave length is computed and the fifty points are plotted on coördinate paper and the best curve is drawn through these points. With proper equipment, two operators can determine the data and plot a spectrophotometric curve in about twenty minutes during a speed test. However, the precision of visual spectrophotometric methods is limited by contrast sensitivity of the human eye and is at best just sufficient for color matching purposes. Since the operator's precision falls off because of fatigue after a few settings have been made, one observer can measure only a very few specimens during a working day. Thus, the visual spectrophotometer is impracticable as a routine control instrument in industry.

Because of the importance of this color problem, there have been many attempts to build colorimeters (as distinguished from color-analyzers) to determine a color subjectively in a single setting. In most of these instruments, the observer looks through an eyepiece at a divided field similar to that used in an ordinary photometer. One-half of the field is illuminated by light from the specimen while the color of the light in the other half of the field may be controlled at will. This control is accomplished through the use of colored light filters in the comparison beam or in any other equivalent manner. At least three independent adjustments are required in order to match all colors successfully. In making a color determination, the observer adjusts the three or more controls until the color in the comparison half of the field seems to match the color in the half illuminated from his specimen. The color sensation produced by the specimen is then recorded by noting the positions of the controls. Although this method is more rapid than the spectrophotometer, a color match is difficult to make and depends to a considerable extent on the personal equation of the individual observer and on various other troublesome factors. Also a colorimeter does not provide as much real information as is given by a color-analyzer. For example, if the instrument is used for control purposes, it will do no more than indicate that the color has departed to a certain degree from the accepted standard. The color-analyzer, on the other hand, specifies in addition the spectral region in which the error has been made, and with the latter information, the procedure necessary to bring the specimen up to the standard color is usually obvious. Thus, we may summarize the relative advantages and disadvantages of the colorimeter and color-analyzer by the single statement that a color-analyzer is the desirable instrument in industry except for the time element involved.

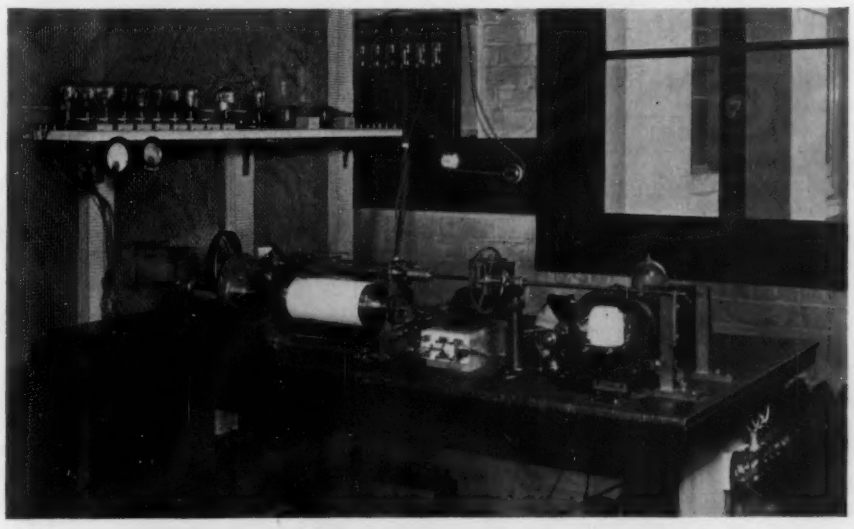


FIG. 2. RECORDING SPECTROPHOTOMETER

A view of the instrument in one of its experimental stages. The sample is placed in a holder just behind the lamp at the right and the curve is automatically recorded on the drum near the center. The time required for a complete analysis is only a few seconds.

A research program begun a number of years ago in the Optical Laboratory of the Massachusetts Institute of Technology has recently resulted in the development of an instrument which does not possess the objectional features of other spectrophotometers. It was realized at the outset of the work that the precision of the human eye was scarcely good enough for colorimetric purposes, particularly in the blue and violet regions of the spectrum. The first step, therefore, was to investigate all of the known photo-electric or photo-sensitive substances or cells. The electric current which may be passed through one of these cells at the illumination levels obtainable in color measurements is only a very small fraction of a micro-ampere. Consequently, it was necessary to devise an amplifier to convert this feeble current into a current many billion times greater. Fortunately, the rapid growth of the radio industry made vacuum tubes of the proper type available so that the amplification problem is not difficult today.

It is impossible in a short article of this sort to describe the many unsuccessful schemes that had to be abandoned before the present instrument was made to perform as it does at present. We can attempt only to outline briefly the salient features of the instrument which has now been operating satisfactorily for some time in the Optical Laboratory of the Department of Physics. The source of light is a ribbon filament incandescent lamp which illuminates both the specimen and a piece of magnesium carbonate used as a standard white. The light from the lamp falls perpendicularly on both the specimen and the standard and produces an illuminaton many fold greater than full sunlight. The light reflected from the specimen and the standard then enters the slit of an ordinary spectrograph system.

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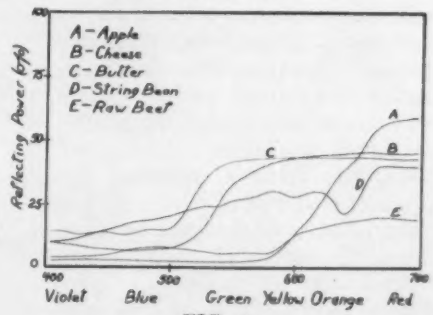

FIG. 5

Typical curves. Although the instrument has applications in many industries, food stuffs were chosen for illustration because their colors are better known.

Electrically Welded Steel Railroad Ties

A novel application of welding science to the reduction of railroad right of way maintenance

By GEORGE A. CHUTTER '21, S.M. '22
Industrial Engineering Department
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THE railroad tie was first employed in connection with horse-car or tramway lines in the latter part of the eighteenth century. Wood was the cheapest suitable material available at that time, and has remained the most popular material through the intervening century and a half, although the weight and speed of traffic has doubled many times. During this period, in other fields there has been a general trend from wood to steel as a material of construction, but in spite of many efforts the attempts to substitute the steel tie for the wooden one has met with little success. Some idea of the importance of the railroad tie may be gained from consideration of the fact that there are six times as many ties as people in the United States and their replacement constitutes one of the largest single items in railroad right of way maintenance.

The function of the railroad tie is twofold, *i.e.*, to hold the track to gauge, and to transmit the stresses from the rail to the ballast. These stresses result in deflections due to the weight of the load carried by the rails, side thrust, due to swaying of the trucks from side to side on the track, and creepage, due to acceleration or deceleration of the train.

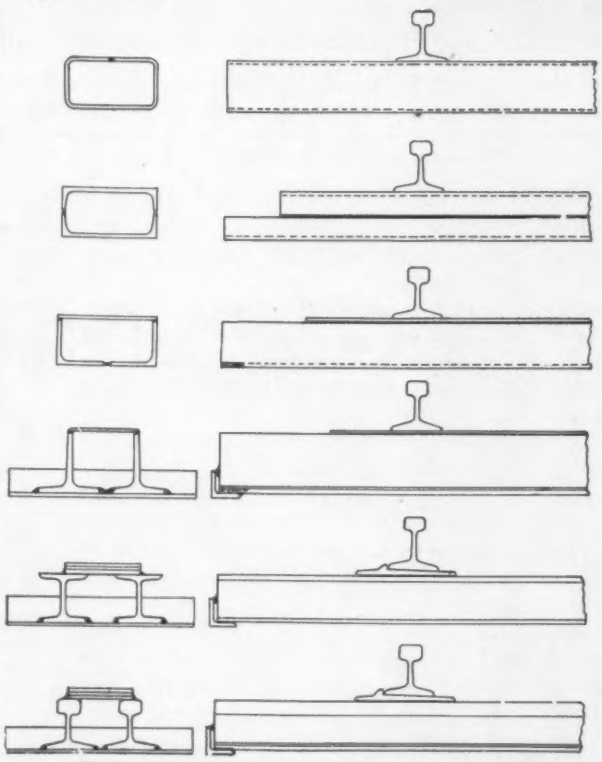
The difficulties to be overcome by the designer of steel ties are threefold; first, the cost; second, the maintenance and reliability; third, provision for insulation for railroad signal systems. Indications are that these problems are nearing solution and the story of their solution is one of the romances of engineering.

If steel ties were to be manufactured from new material it is questionable whether or not they could be made of equal strength as the wooden ties and at the same time compete from a cost standpoint. Therefore, only under special circumstances could the metal tie be expected to compete with the wooden one. However, if it were possible to manufacture these ties from a plentiful by-product material of relatively low value, there might still be some hope of successful competition. One of the by-products of successful railroads is worn steel rails, and the rail is fortunately of such a cross section as to readily lend itself to metal tie construction.

Steel ties constructed from other steel sections available as scrap may be seen in Figure 1. By using worn 90-pound rails, using two pieces per tie, and considering the scrap value of these rails as being approximately $14 per long ton, the cost of worn rails per tie will be approximately $2.80. The cost of fabrication, including the angle iron at the ends of the rail, is approximately $0.65. This figure includes interest, depreciation, taxes, labor, electricity, and electrode material, as well as the cost of flame cutting the rails to the proper length by means of an oxy-illuminating gas flame. This cost, of course, will vary but it is based on a very moderate output of one tie in five minutes with two operators and an automatic tie welding machine described in a later paragraph of this article.

The following is a comparison of the cost of steel and treated-oak ties in certain districts over a period of twenty years:

	Wooden	*Steel*
Cost	$2.80	$3.45
Interest and taxes at 7%	3.92	4.85
Depreciation	2.80	....
Totals	$9.52	$8.30



STEEL TIES CONSTRUCTED FROM SCRAP
It is interesting to note how different sections may be used.

At the end of twenty years the wooden tie would have to be replaced, while under average conditions the steel tie will not have deteriorated to any great extent. The cost of tie plates, welded to the head of the rails, is not included in this cost since the tie plates would be used with the wooden ties and the costs, therefore, offset each other. Similarly, the cost of the spikes is not included, since the cost of the spikes is offset by the cost of the clamps which hold the rail to the steel tie.

The advantages of the steel tie are not entirely apparent from an examination of the costs involved. Much can be said for the increased safety and operating advantages of the steel tie. The steel tie is made of two sections of scrap rails, spaced about 1½ inches apart. This spacing is such that the rock ballast will not pass between the two rails. In this manner a larger surface is next to the ballast, the increase in area being approximately 31% over a 7-inch by 9-inch by 8½-foot tie.

Anyone who has observed the track as a train passed has noticed that the rails and ties have a very decided deflection. This is not due to the resiliance of the rail or the tie, but rather the resiliance of the ballast and soil. The deflection is nearly proportional to the area of the tie supported by the ballast for any given type and condition of ballast. Consequently, the deflection of the track supported by a steel tie will be less, for a given load, than the deflection of the track supported by a wooden tie, assuming that the spacing of the ties was the same in either case. This decrease in the deflection of the rail will mean that the draw-bar pull per ton of load will be less, and at the same time the tendency to fatigue failures in the metal resulting from crystalization will be correspondingly diminished.

In addition to the superiority of the steel tie in resisting forces in a vertical plane, the rail clamp used with a steel tie will withstand side thrust of 150,000 pounds, whereas the spikes used with a wooden tie and tie plate will fail under a side thrust of 15,000 pounds. Sidewise displacement of the steel tie on the ballast is effectively prevented by the angle iron welded on the end of the steel tie (Figure 1). Since action and reaction are equal and

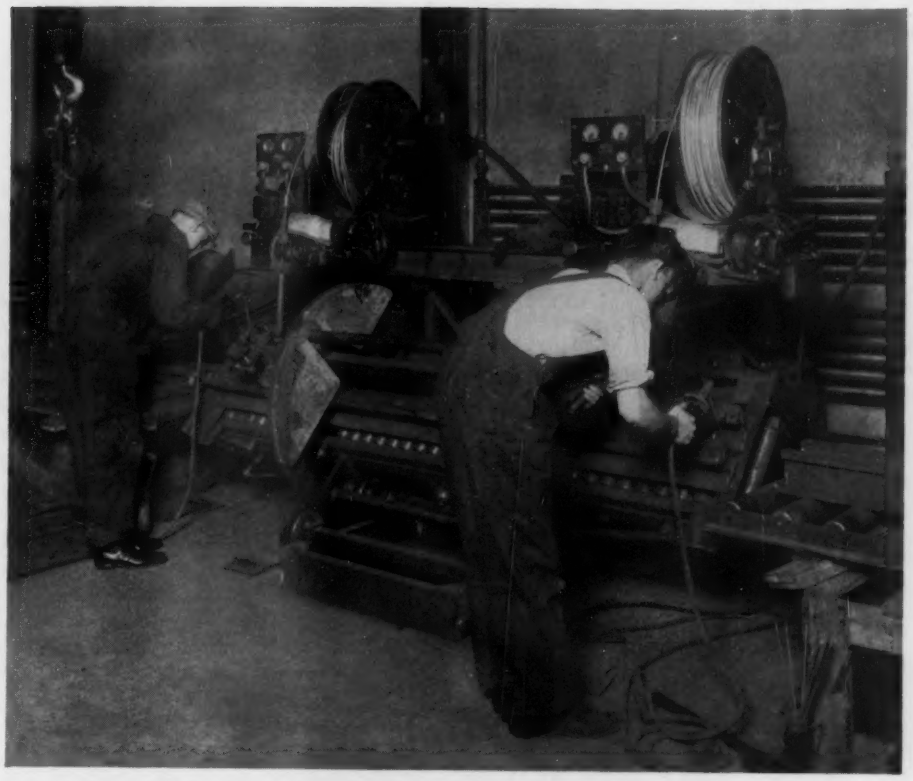


FIG. 4. MACHINE DEVELOPED FOR WELDING TIES
Welders are shown fastening the angle iron to the rail sections.

opposite, there is a tendency to cause the rail to creep on the tie equal to the force which is accelerating the train. For this reason, it is necessary to provide some means of preventing this creepage. This may be accomplished by welding a piece to each rail, which will engage with the rail clamp.

Much of the main line track is now protected by block signals, and since these are operated when the rails are electrically connected through the wheels and axle of a passing train, it is necessary to provide for insulating these rails under normal conditions. While the voltage involved is generally low, the insulating material must be capable of withstanding shocks and abrasions occurring between rail and tie plate, as well as the action of heat, moisture, acid and alkali which are encountered in various localities. Various materials have been tried but the problem is yet unsolved and is a serious limitation to the application of the welded steel tie.

Next to the problem of insulation, the most difficult and most important engineering problem involved in the application of steel ties to railroad service is that of fastening the rail to the tie. Neither bolts nor rivets are satisfactory for making this connection. Vibration in time causes the rivets and nuts to work loose. The additional track supervision and maintenance which would be entailed, as well as the risk involved would alone preclude the steel tie from this service. However, a very ingenious device has been developed for making this connection, shown in Figures 2 and 3. Figure 2 shows a connection suitable for connecting a Universal tie to any size rail. If the tie is to be used with only a single size of rail, the connection shown in Figure 3 would be used. The cotter pin type of clip is actually made of spring steel approximately 1¼ inches wide and so constructed that when once in place, it holds the clip tightly against the other side of the slot. This clip embodies the feature of simplicity, reliability and ease of application.

In addition to the above engineering features, it should be noted that the cost of laying track with steel ties is lower than with wooden ties, since no track gauge need be used, the tie plate aligning the rails and holding the track absolutely to gauge.

In order to manufacture these steel ties from scrap rails at such a cost as to make their manufacture attractive, it has been necessary to devise a special welding machine, an illustration of which may be seen in Figure 4, showing not only the machine, but the welders fastening the angle iron to the ends of the scrap rail sections.

The tie-welding machine is arranged so that the railroads can make their own metal ties. The machine consists essentially of a roller conveyor on which the rails are moved into welding position after being flame-cut to length, a gauge for spacing the rails and locating the tie plates, two pneumatic plungers for holding these tracks in position, a pair of spring and toggle operated clamps for holding the angle irons against the ends of the rails, a mechanism for rotating the whole conveyor with its rails and tie plates, two automatic welding heads mounted on individual travel carriges for welding the two tie plates simultaneously, a track on which the travel carriages ride, and a supporting framework.

The welding heads consist essentially of a control for maintaining proper arc length between electrode and metal by means of raising or lowering the electrode wire. The raising or lowering is accomplished by engaging one of two magnetic cone clutches with motor-driven shafts, one arranged to raise and the other to lower the electrode. The raising or lowering is determined by a contact-making voltmeter across the arc. Power is supplied to this welding machine from a constant potential arc welding generator, two circuits going from the generator to the welding head, and two being available for the manual welding done by the welding machine.

The edge-welds between tie plate and rail heads are made automatically while the operator welds the angles to

(*Continued on page 180*)

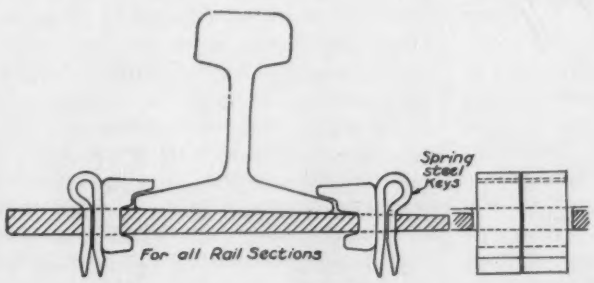


FIG. 2
Showing a connection suitable for joining a Universal tie to rails of any size.

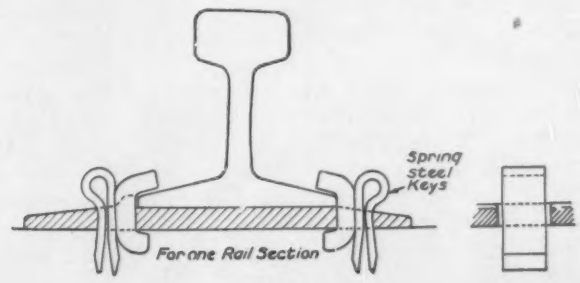


FIG. 3
The connection for a single size rail is shown in here illustrated.

The Division of Simplified Practice

A Government agency which brought about a saving to industry of over $600,000,000 a year

By RAY M. HUDSON
Assistant Director Commercial Standards
Bureau of Standards

A STEADILY decreasing margin of net profit which business has experienced during the last few years has given much concern to American industrial engineers and executives. The number of business failures occurring annually in the United States indicates that in order to survive, an industrial enterprise must be more effectively managed than ever before.

Some of the important causes of these failures and losses are to be found in one or another of the avoidable wastes which exist in so many industries. While there are, of course, innumerable examples of wise and constructive simplifications carried on by individual companies, which have resulted in important savings, wastes are often due to circumstances beyond the control of an individual. Obviously the remedy in these cases must be sought through concerted action by larger groups.

If producers, distributors, and their best-informed customers will take counsel together, it is practically always possible to find a satisfactory cure for economic ills. It is certain that such corrective measures are greatly to be preferred over legislative action. A striking industrial development of the last ten years has been the growing recognition of the value of self-government by industry.

One cause of preventable wastes, which are estimated to exceed ten billion dollars annually, is a desire to make or have something "just a little different" from the other man. This has led to over-diversification in manufacture. As someone has aptly expressed it — "Variety may be the spice of life, but it is not the life of business."

The emergency created by the World War saw simplification applied on a national scale. Indeed the elimination of a great variety of sizes and types for which there was no economic justification was one of the beneficial results of the war. During the period 1918–1921, however, there was a tendency to return to the old condition of great diversity. A number of factors strengthened this trend, among them the so-called "buyers' market" which existed in nearly all post-war industries. The first step toward a remedy was to determine as exactly as possible the current conditions in the production and distribution of manufactured articles.

Accordingly, a committee of seventeen engineers, headed by Herbert Hoover, now Secretary of Commerce, met in Syracuse, New York in February, 1921 and planned a survey of waste in American industry. The subsequent work of this committee is so well known as to require no elaborate discussion. Its findings, published under the title "Waste in Industry" is thoroughly familiar to all students of modern economics.

TABLE I

S.P.R. No.	*Title of Recommendation*	*Degree of Adherence (per cent)*
1	Paving Brick	65
2	Beds, Springs and Mattresses	61
3	Metal Lath	99
5	Hotel Chinaware	80.6
6	Files and Rasps	93
8	Range Boilers	99
9	Woven Wire Fencing	99
20	Steel Barrels and Drums	89.04
28	Sheet Steel for Jobbers	
	Sheet Steel portion	85
	Roofing portion	52
29	Eaves Trough and Conductor Pipe	92
30	Terne Plate	100
32	Concrete Building Units	98
33	Cafeteria and Lunchroom Chinaware	80.6
35	Steel Lockers	85.18
39	Dining Car Chinaware	80.6
40	Hospital Chinaware	80.6
43	Paint and Varnish Brushes	80.5
44	Boxboard	65
46	Tissue Paper	56
46	Tissue Paper	85
51	Die Head Chasers	80.74
55	Tinware, Galvanized and Japanned Ware	92
	AVERAGE — 82.56 per cent	

It will be recalled that the Committee's study of six typical major industries indicated an average waste of approximately 50 per cent. The committee estimated that a large fraction of this waste could be overcome through a broader application of the principles of simplification and standardization. To help make such work national in scope, Secretary Hoover established the Division of Simplified Practice as a part of the Department of Commerce. This Division serves as a centralizing agency through which manufacturers, distributors and consumers can discuss their common problems and decide upon such steps as will prove of benefit to all concerned.

Readers of THE TECH ENGINEERING NEWS should be particularly interested in the experimental years of the Division of Simplified Practice. As a part of the Bureau of Standards, its success was in a measure due to the help and guidance of Dr. S. W. Stratton, then Director of the Bureau, now President of the Massachusetts Institute of Technology. Besides Secretary Hoover and Dr. Stratton, the major credit is due to William A. Durgin, a graduate of Massachusetts Institute of Technology, '02, who came from the Commonwealth Edison Company of Chicago to act as the first Chief of the Division from December 1921 to July 1924. In its work of aiding industry to arrive at a solution of its waste problems, the Department's activities are purely coöperative in character. The initiative and the technical details as to remedial action must come from the industry itself. When a recommendation is made effective, its continued observance depends entirely on the good faith of those who have endorsed it. The Department has no regulatory or police powers to enforce adherence, and all questions requiring decision and interpretation are referred to the Standing Committee, appointed by each general conference which develops a recommendation.

It may be of interest to outline briefly the several steps through which such a waste-elimination program must pass. The first essential is to determine the trend of current production and sales. A survey is made by a committee of the industry, from which are drafted tentative recommendations. These in turn are approved or modified by a general conference of manufacturers, distributors, and consumers. The Division of Simplified Practice then undertakes to secure for the recommendation as widespread support as possible. Should the proposal be endorsed by associations and individuals representing at least 80 per cent of the annual production, the simplified schedule is promulgated through publication by the Department of Commerce. The procedure of the Committee is described in great detail in the

(*Continued on page 178*)

Editorials

THE AERONAUTICAL ISSUE

It is with great pride that the Managing Board and Staff of THE TECH ENGINEERING NEWS present this May number, the Aviation issue, to our readers. For months we have looked forward to the dedication of the Guggenheim Memorial Aeronautical Laboratory as an event which will occupy an important position in the history of the development of aviation. The ceremony also stands as the climax of a long list of achievements in the growth of the Institute, and we consider it a privilege to play our small part in celebrating and commemorating the event.

In view of the fact that THE TECH ENGINEERING NEWS is the official publication of the dedication exercises we are presenting several articles which deal primarily with the building itself from the various standpoints of design, equipment, future use and history. Authors also bring out the prominent position of Technology in the aviation industry of today, and by recounting the past accomplishments of aeronautical research and development here at M. I. T., forecast a brilliant future for the years to come.

At the same time that we are concentrating upon the various phases of our own Department of Aeronautical Engineering, we have gone beyond the boundaries of Technology for articles of a general appeal to those interested in aviation. Consequently, prominent men of the industry have spent valuable time in the preparation of material on technical phases of the subject, such as power plant development, aerial navigation, and aerial photography.

It has always been the sole aim of us of THE TECH ENGINEERING NEWS to publish a magazine which would furnish its readers with essential information upon scientific subjects, and to render to the limit of our ability any services at our command which may be devoted to the benefit of the Institute at large. We hope that this, the Aeronautical issue, does not fall short of that standard.

ENGINEERING AND THE GOVERNMENT

One of the big elements in the party platforms this year will be the question of flood control. How can a politician or the public decide what means shall be taken to control the flow of rivers? In Germany, great laboratories have been built to study the flow of rivers and the construction of harbors.

Flood control is only one of the many engineering problems before the federal government. Muscle Shoals, the Swing-Johnson Bill for the Colorado River, and countless other problems could be cited. These are not political issues. They cannot be decided by a congress of men who have had no engineering experience.

We are fortunate in that we have a group of National Engineering Societies in this country, whose members stand at the top of their professions; men whose ideals are high and who can shoulder the nation's engineering problems with a rich background of experience. Why not remove engineering from politics by having a committee consisting of the heads of all the National Engineering Societies act as advisors to Congress, decide what is to be done, and then have Congress follow their recommendations? So large a portion of the government work involves engineering in some form that we certainly feel justified in asking for some technical men who have the authority to act, to replace the log-rolling politician with a grammar school education as our chief engineers.

THE COVER

We take great pleasure in presenting to our readers a charcoal sketch by Prof. Charles Fayette Taylor of our Aeronautical Engineering Department, showing the Loening Amphibian with a radial engine in flight.

HUMANICS

In this day of mediocrity, standardization seems to be the goal not only of the students, but of the colleges themselves. The modern tendency toward reducing all supposedly applied knowledge, such as plumbing and carpentry, to textbook work may be all very well, but its practical limit is very soon reached, and from then on only actual practice is of any use. It is therefore with extreme gratification that we see appearing a new chair in Humanics, founded by Mr. William E. Nickerson, a man who has apparently made it his life study. In the words of President Stratton, "The course is designed primarily for systematic preparation to meet the problems of human relationship in business and industries."

Realizing that the wisdom to apply knowledge, honesty, loyalty, tact, patience, and the ability to make decisions, are the great qualities which make for success, Mr. Nickerson has felt that a course should be designed in which these things are stressed in such a way as to make the student understand just what is ahead of him in his business career. Though we do not know Dr. Charles A. Gow, the man who is to hold the chair, his record shows that he is among the best of our engineers; has had much field experience with an abundance of personal contact.

As is usual in the instituting of such a new course, much responsibility rests upon the shoulders of the professor in charge, but in view of Dr. Gow's achievements, it would scarcely seem probable that he will encounter any undue difficulties. In spite of the cooperation which we are sure he will get from the students, we hope that results will not be demanded of him too quickly, as the value of such subjects cannot be measured except by the passage of years.

THE TECHNICAL TRAINING

Years ago, it was the custom, for those who were financially able, to obtain a "gentleman's education" before entering upon their professional studies, on the theory that it paid to develop one's mind in a cultural way and train to study before taking up the field in which one intended to specialize. For a person to receive a technical training before entering upon a study of law would be considered to be the height of folly. Nevertheless, we rise to defend the technical education as a basic training for the mind.

In a cultural school, the student tends to acquire a "scholarly" attitude towards life which unfits, or at least handicaps, him for any profession other than teaching. Furthermore, he does not get a mental schooling that compares in any way with that obtained at a scientific college. The ability to think clearly and logically, and to grasp a problem and work it through to a successful conclusion, is possessed by the technically trained man to a much higher degree than by his liberal college brother.

Moreover, the amount of work required is usually greater and infuses into him a mental energy and concentration which is lacking in the cultural scholar. It seems to us that no training fits one for life or further study as much as a technical one. Few engineers use as much as one-tenth of what they studied, but the mental stimulation and exercise which they have received in their undergraduate days stands them in good stead and is responsible, in a large measure, for their success, whether it be building bridges or selling shoes.

Departmental Notes

FUEL AND GAS ENGINEERING

WITH the rapid depletion of our country's supply of liquid, gaseous, and solid fuels, and the consequent increase in price, the need for an increase in the efficiency of utilization of fuels has become ever more important. There has arisen, therefore, a demand for men especially trained in this particular field who would be able to cope with the many new problems confronting the industries connected with the processing and utilization of fuel.

To meet this demand the Institute established, in 1925, a graduate course designed to give to students, having the fundamental engineering training obtained in most of the undergraduate courses at Technology, the specialized training in fuel technology which would enable them to occupy positions as fuel engineers. That the establishment of this course was not unjustified is indicated by the reception which industry has given to those students who have completed the course.

The course consists of two terms of theoretical work at the Institute followed by six months of practical work at the various field stations. The value of the training obtained in the field can hardly be overemphasized. Following as it does the work at the Institute, it gives the student an opportunity to apply his knowledge to plant practice under the supervision of one of the Institute faculty. During this period at the field stations every effort is made to develop in the student a feeling of self-confidence and an ability to make decisions. For this reason the groups are kept small, and during any particular investigation the work is directly in charge of one of the students known as the group leader. Every student is a group leader one or more times during his stay at each station. The director of the station is always available for consultation.

The Institute has been particularly fortunate in its choice of locations for field stations. Those located at the Cambridge Gas Light Company, Iroquois Gas Corporation, and Bethlehem Steel Corporation have already been mentioned in TECH ENGINEERING NEWS. Since then, however, two additional stations have been established — one at the Bayonne refinery of the Tide Water Oil Company, and another at the Edgar Station of the Edison Electric Illuminating Company of Boston. The establishment of these five stations quite completely covers the field of industries connected with the utilization and processing of fuels.

It has been interesting to note the wide latitude of the previous training of those who have so far completed the course. The list includes graduates in Physics, Electrical Engineering, Mechanical Engineering, Chemical Engineering, and Chemistry. Even with this diversity of previous training, all of them handled the course satisfactorily, and all are now doing notable work as fuel engineers. It has been gratifying to the department that the industries have been so quick to recognize the advantage of specialized train-

PROFESSOR J. T. WARD

ing in fuel engineering. There has been so far an average of three positions open for every graduate in this course, and the average starting salary for these men appears to be considerably higher than for men holding a Master's degree in other branches of engineering.

In addition to the regular courses offered, the department is also carrying on considerable research. This work may be divided into three main headings — thesis direction, departmental research, and coöperation with outside organizations.

Besides the thesis work undertaken by students in the course, the department offers each year a number of theses which may be taken by students from any department. At the present time there are thirteen of these thesis students working under the direction of various members of the department. Among the problems being investigated is that of the synthesis of liquid hydrocarbons from water gas at atmospheric pressure. From the reports of the United States Geological Survey it is apparent that in a comparatively few years our supply of petroleum will be exhausted. In order that we may be prepared when that time does come, it is desirable that methods of synthesizing liquid fuels be perfected, and to that end this investigation is being carried on by this department. It is obvious that no one student can solve the problem completely in the short time allotted for thesis work, but by continuing the work from year to year and having different students take up different phases of the problem and then coördinating the results of the separate investigations, it is apparent that a great deal may be accomplished.

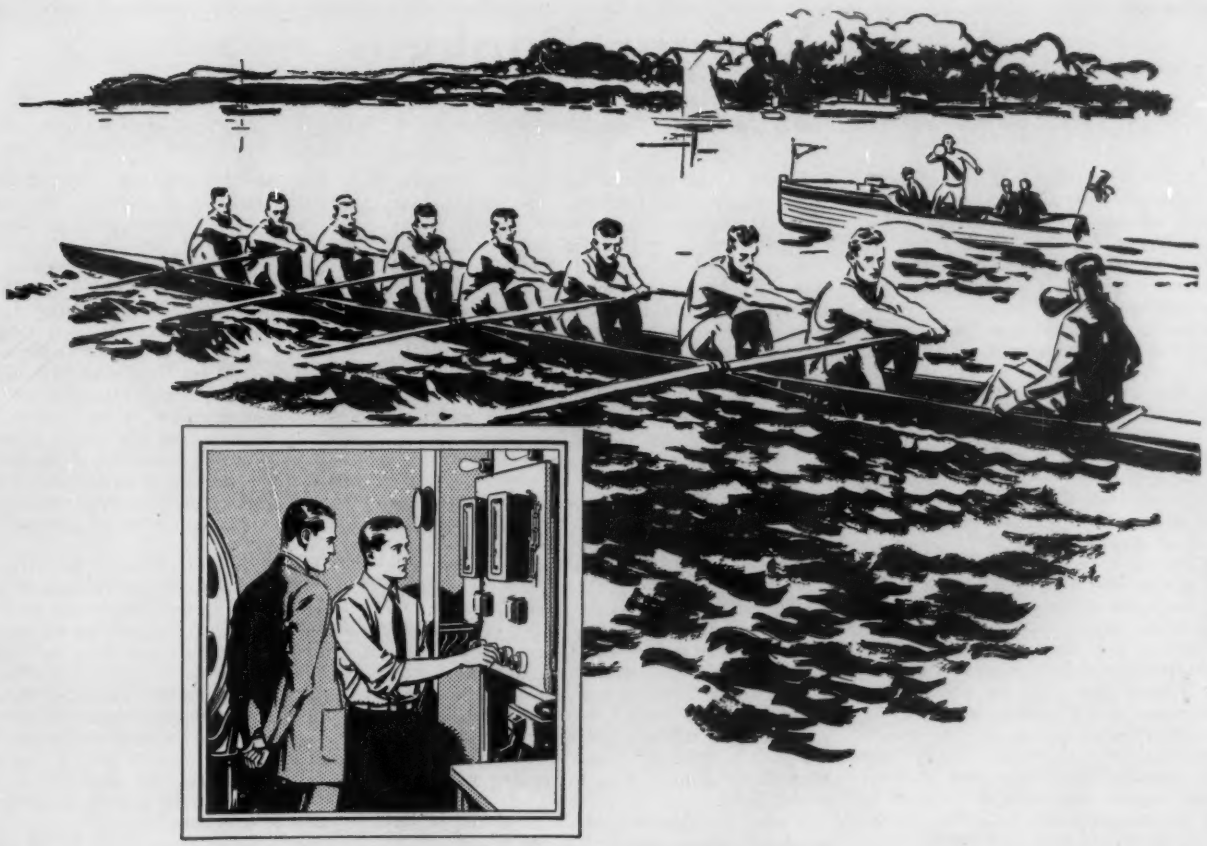
Another thesis problem being investigated is the elimination of sulfur from the coke of high sulfur coal. There are available in the middle western states huge quantities of coal suitable for coking into good metallurgical coke, the only difficulty being that they contain too high a percentage of sulfur. It is necessary, therefore, that steel plants located in the Middle West ship coal or coke from the eastern fields and pay large transportation charges. If it is possible to produce a low-sulfur coke from the high-sulfur Illinois and Indiana coals, enormous savings will be possible for the steel plants.

Other thesis studies include an investigation of domestic stokers, studies on the constitution of coal, and an investigation of the reactions in the cylinders of internal combustion engines.

Research is being carried on at all times by members of the department. Probably the most important recent contribution is that by Hoyt C. Hottel, '24, on radiation in furnaces. The factors involved in the transfer of heat from flames and from the non-luminous products of combustion are very numerous, and because of their complexity many of them have been neglected in the past. Hottel has, however, taken up each one of the factors in turn and has reduced them to comparatively simple expressions which greatly simplify and make more accurate the design of equipment concerned with the transfer of heat.

Since its origin, Fuel and Gas Engineering has been coöperating with various outside organizations in the investigation of their research problems. A great deal of work has been done in conjunction with the American Gas Association. It has long been known that cokes produced in various types of carbonizing equipment had widely different properties even when the same kind of coal was used in the vari-

(Continued on page 168)



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Recent Books

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DIESEL ENGINES. *By* A. P. CHALKLEY, B.Sc. *With introduction by the late* DR. RUDOLPH DIESEL. *Sixth edition. D. Van Nostrand Company, 1927. 320 pp. Illustrated.*

Anyone expecting in this volume a complete treatise on Diesel engine theory and practice will be greatly disappointed, for it is in no sense of the word a treatise, nor does it more than scratch the surface of the theory of internal combustion oil engines.

However, it provides an excellent résumé of the oil engine as it is today, or rather, was a year ago. And it may be said here that even in such a short time many of the views expressed by the author are already passé, so rapid has been the progress in the Diesel field in the past two or three years. Since the date of writing of Chalkley's book we have seen the balance of favor swing from the four cycle to the two cycle type in the marine field, and the building of the huge two cycle double acting engines which have made possible oil engine installation in large passenger liners such as the *Saturna*.

This book with its excellent collection of plates and cuts will be a very valuable work to the operating engineer, though of little import to the man interested in theory and design. To a man well acquainted with oil engine theory, the material is undoubtedly all "old stuff." However, I should heartily recommend the book to the student who knowing little or nothing of the oil design field desires to gain an "insight" into this newest form of prime mover.

J. H. BOOTH, JR.

PROBABILITY AND ITS ENGINEERING USES. *By* THORNTON C. FRY. *D. Van Nostrand Company, Inc., New York, 1928. XIV and 476 pp. Price $7.50.*

The author of this interesting and original treatise is a member of the technical staff of the Bell Telephone Laboratories at New York. He is not a stranger to M. I. T., for he delivered a course of lectures on the same subject in the Electrical Engineering Department during the second term of last year. Indeed, it was in this course that he finally revised his notes which have now been published by the Bell Telephone Laboratories as this textbook.

There is not in any language a textbook on the theory of probabilities that fits more admirably the needs of the engineering student. The most interesting examples are taken from the field of actual technical applications, especially from telephone practice. The book also gives a good introduction into the more abstract part of the theory and thus gives a very satisfactory exposition of the most important parts of the whole field.

Starting with permutations and combinations, the author soon comes to a discussion of the ordinary urn, cords and dice problems. One chapter is devoted to a very clear exposition of Bernoulli's theorem, another to Bayes' theorem. In this chapter an application to a problem in screw sampling clearly exemplifies the author's interest in practical applications. In the later chapters, the number of such examples increases. Passing to continuous probabilities, the author comes to a more detailed discussion of distribution curves. The next chapter introduces the different averages in a very clear way. Then there follow in three chapters, taking together 150 pages, the statistical parts of the theory with applications to curve fitting and congestion problems. In accordance with the modern Scandinavian authors, not only the normal (Gauss) law, but also the Poisson law is fully discussed and its use in practical problems explained. Among the topics treated in these chapters we may mention the Pearson curves, the Gram-Charlier series, Weldon's dice data, problems of lost traffic, computation charts, individual and group hunting. The last chapter is a short introduction into statistical mechanics with application to the Schottky effect. The book ends with 43 pages of tables. In accordance with the Anglo-Saxon custom there are many problems in the text for the student to solve. Special reference should be made to several interesting and well-prepared figures, many representing distribution curves.

From a mathematical point of view much might be said about the conceptions explained in this book — as is true of every textbook on probabilities. We have to do with a science with mathematical foundations as yet imperfectly understood. The author — and we believe he is right — is opposed to the axiomatic conceptions introduced in books such as that of Coolidge. In his criticism of these conceptions he does not, however, assign full importance to the work done by Poincaré, Borel, Lomnicki, and others on this subject. The mathematical theory of probabilities must be based on the mathematical theory of measure, the corresponding theory of summation and on a theory of iteration. In a textbook which maintains such a high standard, even if it is primarily intended for engineering students, we have a right to expect a certain influence from these sources, *i.e.*, in dealing with zero probabilities.

We believe that ampler historical and bibliographical notes would add to the readability of this very readable book. We have, however, in the recent book of Arne Fisher a treatise from a related standpoint which adequately fills our needs in this respect.

D. J. STRUIK.

THE THEORY OF STRUCTURES, Third Edition. *By* CHARLES M. SPOFFORD, S.B., '93, *Hayward Professor of Civil Engineering at the Massachusetts Institute of Technology. McGraw-Hill Book Company, Inc., 1928. 587 pp.*

The third edition of this textbook is revised and enlarged from the earlier editions and the subject matter of the former issues has been changed but slightly. This includes Chapters I to XIII, XVII, XVIII and XIX. The new material deals mostly with statically indeterminate structures, though there are treatments of deflections which were not included in the earlier editions. The method of presentation of the new material is similar to that used in the old part of the book, *i.e.*, a clear development of the method of applying certain well-known laws of Mechanics to the problem under consideration, with an algebraic illustration, followed in the more complex problems, by a numerical example. Since the earlier editions are well known and have changed but slightly, only the new material will be discussed here.

Chapter XIV has been extended considerably, without omitting any of the older material. The application of the method of virtual work to the determination of the deflections of beams has been extended to cover the computation of change of slope. The computation of truss deflections by the method of elastic weights has been added, being developed by the application to a simple end-supported span and being further illustrated by the application to a cantilever truss and to a truss with subdivided panels. Maxwell's theorem of reciprocal deflections is developed, as is also a treatment of the deflection and change of slope of a beam by the method of moment areas.

Chapter XV has replaced Chapters XV and XVI of the second edition and contains the following new material: a treatment of the application of the method of deflections to the determination of the reactions for continuous girders; the method of applying the principle of virtual work to the computation of the stresses in trusses with redundant reactions or with redundant bars; the method of applying the theorem of least work to the computation of framed bents and the method of slope deflections as applied to the computation of framed bents.

The new Chapter XVI deals with the computation of the stresses in statically determinate space frameworks and contains several numerical examples, including a Schwedler Dome.

Chapter XX has been rewritten and some of the recently developed formulas for the most advantageous shape of an arch rib and for variation of cross-section have been quoted. This is followed by the derivation of the formulas for the fixed-ended arch as in the previous edition. The numerical examples have been extended to include the determination of some of the influence lines.

Chapter XXI is devoted to a discussion of some of the approximate methods of computing the stresses in framed bents such as are used in high buildings. It includes numerical examples illustrating the effect of making particular groups of assumptions as to the distribution of horizontal load among the several columns or as to the location of points of contraflexure.

These additions should make the book still more valuable as a text than it has been, particularly for those who desire to extend their field of study into the field of the statically indeterminate structure.

W. M. FIFE' 21.

THEORY OF VIBRATING SYSTEMS AND SOUND. *By the late* IRVING B. CRANDALL, PH.D., *Bell Telephone Laboratories. D. Van Nostrand Company, New York City. 272 pp., 24 diagrams.*

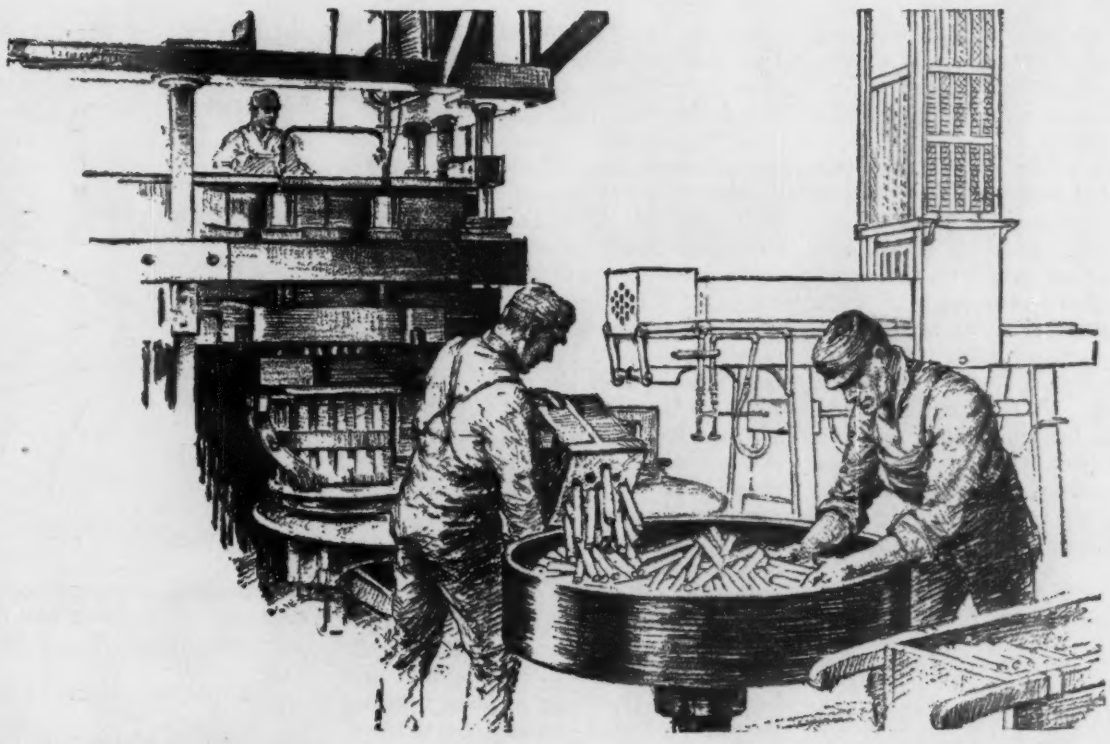
This book gives a mathematical treatment of the basic theory of vibrating systems and sound and its application to current problems particularly those in the study of communication. The mathematical treatment is so highly developed, that it is not a book for a beginner in the study of acoustics, but rather for the more advanced student, one who has had a good background in the use of Generalized Coördinates, Lagrange's Equations, Bessel's Functions, etc.

Solutions for free and forced vibrations of systems such as strings, membranes, plates, resonators, coupled systems, acoustic filters, etc., are given in Chapters One and Two. Chapter Three is devoted to a discussion of the propagation of sound, plane and spherical waves and the effects of the medium on vibrating systems. Chapter Four deals with radiation and transmission problems and the treatment of horns, particularly the finite exponential type. Chapter Five includes a unique discussion of problems of interest in acoustics of buildings.

Throughout the book, many references are given to such classics as Rayleigh's Theory of Sound, Lamb's Dynamics of Sound, W. C. Sabine's Collected Papers, as well as to a number of contributions which have originated in the Bell Telephone Laboratories.

Two features are incorporated in the book which are especially appealing. First, at the beginning of the text, a table of all symbols used throughout the book, is given with their proper definitions. This is a valuable aid to the reader. Second, in Appendix B, references are given to practically all of the recent published developments in applied acoustics. Most of this material has not been published in book form, so that such a feature is of particular value to one interested in acoustical research.

The book, which radiates much of Dr. Crandall's genial personality, is especially interesting to students at Massachusetts Institute of Technology, since most of its contents was presented in classroom form by the author to students in VI_c and VIII during the second term of 1926.



IT'S THE MAN THAT COUNTS

THE human element probably plays a more important part in the making of explosives than in any other manufacturing process conducted on a large scale. There is no machine in the great Hercules plants that has not a man for its master. Every motion it makes is watched. The results of its work are carefully checked. Nothing is ever taken for granted. No machine is looked upon as infallible.

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Avigation

(*Continued from page 142*)

This is rarely the case, due to changes of the barometric pressure and as the altimeter registers the height above sea level and not above the ground immediately below.

Knowing only the drift angle, the avigator has not sufficient information by which to correct the course. However, if the drift angle is small, the course may be altered into the wind by an angle equal to the angle of drift. Since the wind will have a different effect on the airplane after the course is altered, the drift should be again measured, and if this drift, when applied to the heading, does not give the desired track, the course should again be altered by this difference.

In the velocity triangle, the lengths of the three sides are the ground speed,

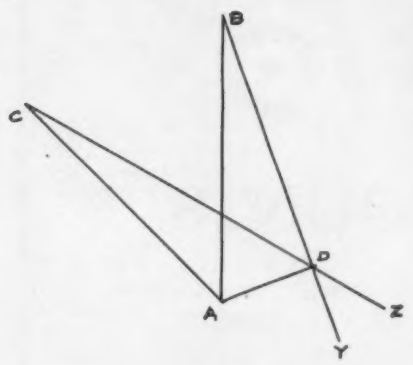

FIG. 7

air speed and wind speed, respectively, and the directions of the three sides are (*a*) the direction of the airplane over the ground, (*b*) the direction of the airplane through the air, and (*c*) the wind direction. In a triangle, if two sides and the included angle or one side and two angles are known, the triangle may be solved. Due to the inability to measure the ground speed accurately, a velocity triangle cannot be solved with a single drift measurement. By measuring drift on two or more courses in quick succession, the desired data may be obtained by the wind star method. This method is based on the principle that any number of drift lines plotted for the same number of courses under constant conditions of wind speed, wind direction and air speed intersect in a point. This intersection has a definite relation to the wind speed and direction. It is best illustrated by the following example:

An airplane with 100 m. p. h. flies on due north course and finds there is 20° left drift. On Figure 7, AB represents the plane's speed and direction through the air. Laying off BY in direction $160° = 360 - 20 - 180$ gives YB, the direction the airplane travels over the ground. Not knowing ground speed, the length of this side cannot be laid off, and wind speed and direction cannot be drawn. If now the plane is headed on a 315° course and a 15° left drift is found, the construction may be continued by laying off AC, 100 miles to scale in direction 315°, and from C drawing line CZ in direction $120° = 315 - 15 - 180$. The intersection of BY and CZ may be called D. Then DA is the direction from which the wind is blowing 73°, and the length of DA is the speed of the wind, 34 miles. DB and DC are the ground speeds, 95 m. p. h. and 119 m. p. h. on the first and second courses respectively.

On many military missions, the destination is a moving and not a fixed objective. Fighting planes must take-off and meet and destroy enemy planes. Pursuit airplanes must meet friendly bombing airplanes to convoy and protect them. Bombing airplanes go out to sea and sink enemy battleships. Problems of interception are solved graphically and the following examples will illustrate the method.

Example 1. An enemy bomber is over point A (Figure 8), flying due east with an air speed of 70 m. p. h. A pursuit plane (with air speed of 85 m. p. h.) is at B, 80 miles south of A, and is to intercept the bomber. There is no wind.

Solution. Lay off on desired scale point B, 80 miles due south of A, and connect A and B. From A draw AC, 90°, the bomber's course. Along AC lay off the distance flown by the bomber in one hour, determined by the bomber's air speed of 70 m. p. h. $= AX$. From X draw XY parallel and equal to AB. From B, point of departure of the pursuit plane, swing an arc with a radius equal to the distance the pursuit plane flies in one hour, 85 miles, cutting XY at D. Join B and D, continuing the line until it cuts AC at P. Then BD is the pursuit plane's true course = 55° true. YD represents "rate of approach" = 50 m. p. h. BA represents total distance of approach = 80 miles. The distance of approach

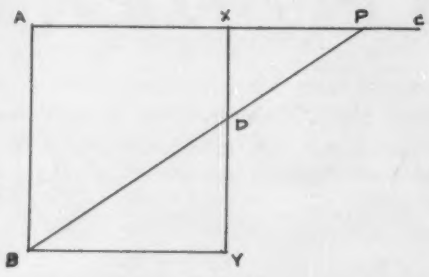

FIG. 8

BA, divided by the rate of approach YD will give the length of time taken for interception, or $\frac{BA}{YD} = \frac{80}{50} = 1$ hour,

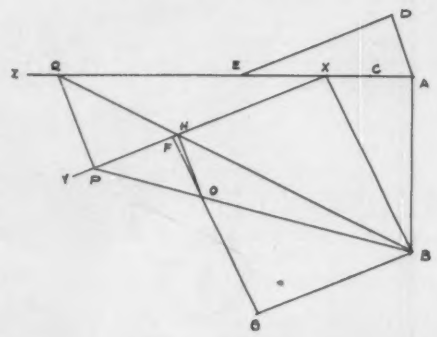

FIG. 9

36 minutes. P being the point of interception, the bomber will fly 113 miles (distance A to P) at 70 m. p. h. in $\frac{113}{70}$ hours or 1 hour, 36 minutes, and the pursuit plane will fly 139 miles (distance B to P) at 85 m. p. h. in $\frac{139}{85}$ hours or 1 hour, 36 minutes.

Example 2. An enemy bomber is observed at 9.00 a.m. over point A (Figure 9), and over point C at 9.15 a.m. Point C is 20 miles due west (true) from A. Our pursuit squadron is located at B, 80 miles due south (true) from A. After receiving report from C at 9.15, a pursuit plane (with 100 m. p. h. air speed) takes off at 9.30 to intercept the bomber. The wind is blowing 30 m. p. h. from 160° (true).

Solution. From A lay off AZ, the bomber's track, 270° and locate C, 20 miles to scale, from A. From A lay off on AZ a point X, the bomber's position at 9.30. As the bomber goes from A to C, 20 miles, in 15 minutes, its ground speed is 80 m. p. h. and AX is therefore 40 miles. Join B and X. This represents the relative position of the two airplanes when the interception begins. BX is the distance of approach, which is 88 miles.

The first step is to find the bomber's true course. From A lay off AD, 30 miles to scale and in direction 340° (160° + 180°), to represent wind speed and direction for one hour. On AZ lay off 80 miles, the bomber's ground speed, AE. Join D and E. Then DE represents the bomber's true course 248° and air speed 75 m. p. h.

From X lay off XY parallel to DE. This represents the bomber's course from point at which time interception begins. Along XY lay off XF equal to

(*Continued on page 164*)

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Aircraft Power Plants

(*Continued from page 137*)

craft have been operating on eighty to ninety per cent rated power, which does not leave sufficient reserve.

Higher speed is essential, as upon it the future of aviation depends. Commercially a cruising speed of 100 m.p.h. has been considered satisfactory in the past. This year a number of planes will be put into service capable of 120 m.p.h. cruising speed. This cuts half a working day off the mail time from New York to San Francisco. A cruising speed of 150 m.p.h. does not seem improbable in the next few years, and this will halve the transcontinental time.

In summing up the development to date it is obvious that air-cooled engines constitute the major part of the American engine builders' output and that it is likely this same condition will pertain to European engines in the next year or two. The rapidly increasing demands of commercial aviation are making themselves felt, and before long there will be a considerable difference between the strict military engine and that used for transportation purposes. The commercial engines will be, in general, simpler and, therefore, cheaper, as well as longer lived, which may entail certain modest increases in weight. Efficiency is bound to be given a great deal of consideration in all new designs. It is hard to predict future developments, since the possibilities of air-cooled engines are just beginning to be studied.

Avigation

(*Continued from page 162*)

the bomber's air speed of 75 m. p. h. From F draw FG parallel to XB. From B draw BG parallel to XF. With B as center and the pursuit plane's airspeed of 100 m. p. h. as radius, cut FG and call point O. Join B and O, extending the line to cut XY at P. Then

BX = distance of approach = 88 miles.
GO = rate of approach = 60 m. p. h.
BO = pursuit plane's course in air = 284°
P = point of intersection in air.

Then length of time for interception will be $\frac{BX}{GO} = \frac{88}{60} = 1$ hour, 28 minutes.

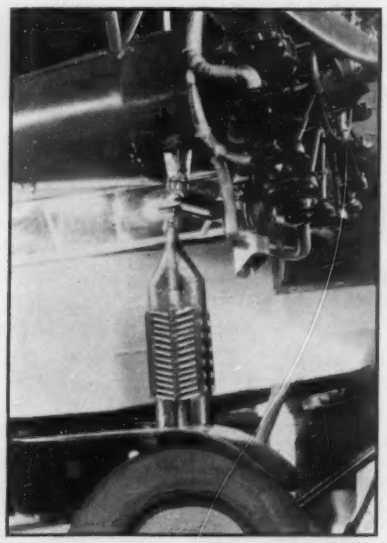
Now, although P is point of interception in the air, it must be remembered that a 30-mile wind from 160° has carried both the bomber and the pursuit plane in a 340° direction and it will be necessary to find the pursuit plane's track in order to determine point of interception on the bomber's track or actual point of interception.

From O lay off OH at 340° representing wind for one hour, *i.e.*, at end of one hour the pursuit plane, while at *O in the air* will actually have been carried by the wind to H. Then BH will represent the pursuit plane's track (284) and ground speed, 120 m. p. h.

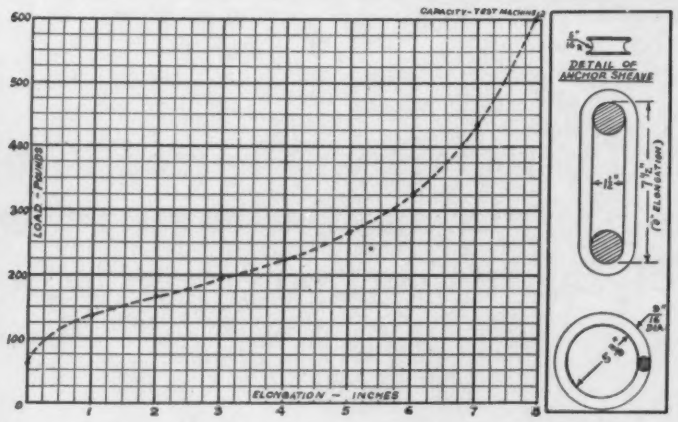
Q is the point on the ground over which the interception actually takes place.

Sea navigators have for centuries used astronomic observations for determining the position of their ships when on a voyage. Such methods are the most reliable means yet discovered for accurately finding position where no landmarks are visible. It has been successfully applied for transoceanic flights by Alcock and Brown, Hawker and Grieve, the R-34, Continho and Saccadura, and Hegenberger and Maitland. While finding the geographic location involves the lengthy solving of an oblique spherical triangle, methods have been developed which reduce the time required to only a few minutes.

Of course, the radio is another means now being used to determine the location of one's position. The developments in this line are of much importance, and the use of this method is destined to be of increasing value in the field of aviation.



Typical Installation of Rusco Aero Rings
On Fokker Tri-Motored Transport



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But in these accomplishments there is the pride that comes from making even the most inconspicuous of products so much better than any one has made it before that men whose lives *depend* upon it, *select* it.

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Ball Bearings — SKF Puts the Right Bearing in the Right Place — Roller Bearings

1884

Color in Industry

(*Continued from page 153*)

Just in front of the slit is a rotating glass disk which has alternate silvered and transparent segments. The disk is so located that light from the standard enters the slit when a transparent segment is in the beam and light from the specimen when a silvered segment is in the beam. The spectrograph system disperses the light and a second slit selects the proper wave-length band. Light passing through the second slit falls on a photo-electric cell which receives monochromatic light of pulsating intensity when the standard and specimen reflect different amounts of light in this spectral region. This pulsating light intensity is changed to a pulsating current by the photo-electric cell, is amplified, and is employed to run a small motor. This motor actuates a shutter in the beam between the light source and the standard, and automatically finds a position where the pulsations of the light cease. This position is, of course, independent of the characteristics of the photo-electric cell. A pen is attached to the mechanism controlling the shutter to record the reflecting power of the specimen on a rotating drum. A second motor rotates the drum and at the same time drives the slit through the spectrum, thus giving a complete color analysis in a time which has recently been reduced to approximately fifteen seconds. In other words, a color analysis now takes no longer than is required for the measurement of some of the simplest of physical properties.

Theoretically, there is no limit to the precision of a photo-electric spectrophotometer like there is in visual instruments. Practically, however, there are noises in vacuum tubes and other disturbing influences which must not be great enough to affect the final results. It is therefore convenient to divide the precision discussion into two parts and to consider separately the reproductibility and the accuracy of the present instrument. Fig. 3 shows a typical test of the former. The sample in this case happens to be a piece of green silk and the machine was made to trace the curve twice. The two superposed curves show that the reproducibility is well within one per cent at every point.

It is somewhat more difficult to test the accuracy of a spectrophotometer intended primarily for measuring the color of reflecting surfaces. However, through the courtesy of Mr. Priest of the Bureau of Standards at Washington, we were able to obtain a specimen of colored glass with its absorption curve as determined with great accuracy at the Bureau. This glass plate was inserted in the beam of light between the sample and the slit, using a piece of magnesium carbonate for the sample, in this case. The resulting curve is shown in Fig. 4 where the circles represent the values obtained by the Bureau of Standards for the same specimen. It will be noticed that there is a rather serious error in the red and orange regions of the spectrum. However, since this curve was made the cause has been traced to the faulty cutting of the wave-length cam which is being remedied as this article goes to press.

This instrument is still, of course, in the laboratory stage and there has not been time to test its applicability to all of the industries which were enumerated above. A sufficient number of tests have been made, however, of the sort shown in Fig. 5 to indicate that the instrument will be of considerable use in many lines of industry. At the present time, work is going forward on a second model which will be considerably simpler than the first, both to construct and to operate.

WIRE automobile and airplane wires, electrical wires, submarine cables, bridge-building cables, wire rope, telegraph and telephone wire, radio wire, round wire, welding wire, flat wire, star-shaped and all different kinds of shapes of wire, sheet wire, piano wire, pipe organ wire, wire hoops, barbed wire, woven wire fences, wire gates, wire fence posts, trolley wire and rail bonds, poultry netting, wire springs, concrete reinforcing wire mesh, nails, staples, tacks, spikes, bale ties, steel wire strips, wire-rope aerial tramways. Illustrated story of how steel and wire is made, also illustrated books describing uses of all the above wires sent free.

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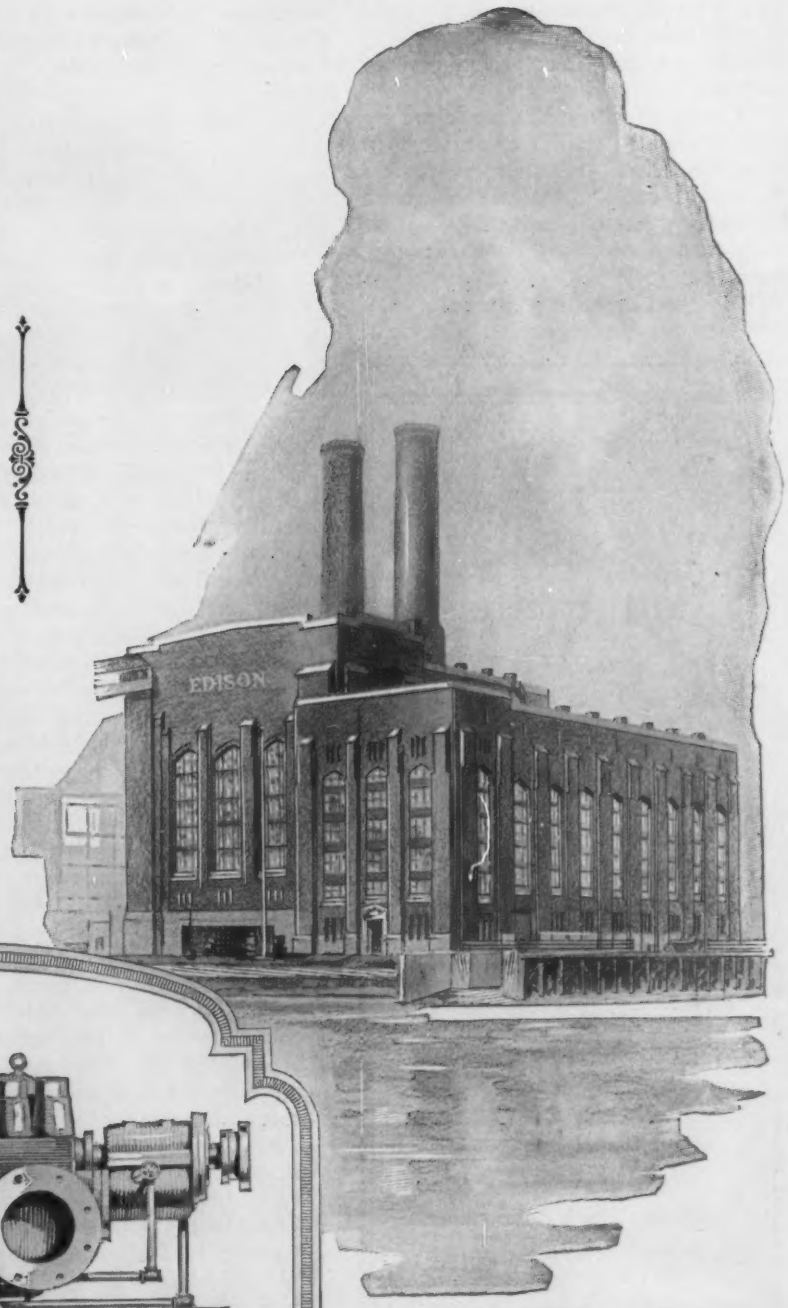

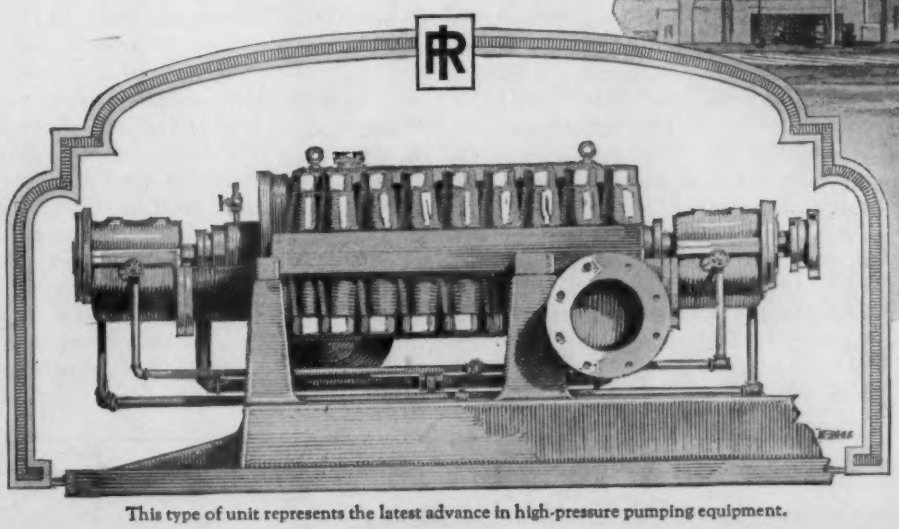

This type of unit represents the latest advance in high-pressure pumping equipment.

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A.S CAMERON STEAM PUMP WORKS

Health Education

(*Continued from page 149*)

people who are changing from an agricultural to an urban existence.

These considerations raised certain questions:

1. Could a technic be developed by which the health habits of children in the public schools could be improved?
2. Could such a technic be made sufficiently practical to be adapted as a natural and desirable part of public school machinery?
3. Would the change in habits secured through such a health education procedure be sufficient to produce an actual and measurable improvement in the health of the child?

Health Education Research

In order to answer these questions a series of studies was planned under the direction of Prof. W. T. Sedgwick just before the latter's death. Researches in this field have been carried out by the department since that time mostly in the city of Malden where the school department has furnished splendid co-operation. There is not space here to describe these studies. They have been reported in the *American Journal of Public Health* and the *Journal of the National Education Association.*

Briefly, this is what was done. A carefully planned health education program was introduced into two schools and the children in two comparable schools were used as a control group. Data collected by observation, inspection, case studies, and questionnaires from pupils, teachers and parents demonstrate an appreciable improvement in habits as the result of the health training. These improvements in diet, rest, posture, cleanliness, etc., apparently gave to the children a regimen which produced better health and thus allowed a more rapid and natural growth. A careful statistical analysis of the growth records for the experimental and control groups shows that the difference in growth between the two groups, was four times the probable error of the difference. In other words, this difference in growth rate was real and significant; it was not accidental.

The experiment in these two schools was so successful and acceptable to pupils, teachers, school officials and parents that the program has been expanded to include all pupils in the Malden public schools. A director of health education with an assistant has been put in charge of this work. Last year the city of Cleveland, Ohio, made use of our studies in organizing a health education program for its one-hundred forty thousand schoolchildren, and subsequently they appointed a former instructor in Course VII as Director of Health Education. During the period of this study we have also been training students to become leaders and supervisors in health education. A sufficient number of these health educators have already been trained so that over six hundred thousand pupils are already under the direct supervision of our graduates. Other graduates who have taken state and national positions are influencing several times that number of children in a less direct way.

The Future

Our researches in this field are continuing to the extent of our available funds. Other institutions in various parts of the country are rapidly developing work along these lines. The World Federation of Education Asso-

(*Continued on page 170*)

Departmental Notes

(*Continued from page 158*)

ous plants. The department has conducted a long series of tests to obtain a quantitative measure of these differences when the coke is used as a domestic fuel and as fuel for water gas generators. The American Gas Association has sponsored four tests of a month's duration each on four different types of carbonizing equipment in order to observe the differences in yields, operation and efficiency. Two of these tests, which are of great value to the gas industry, have been carried out under the direction of members of the department.

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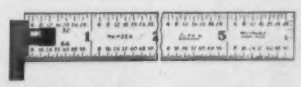
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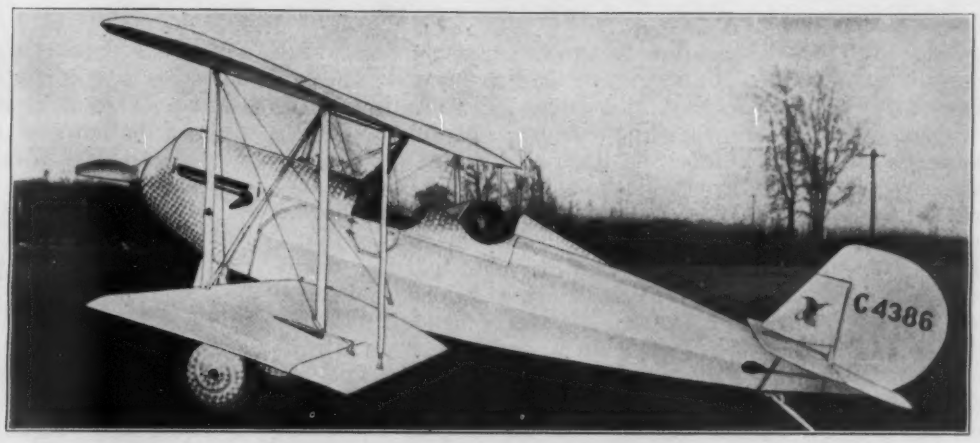

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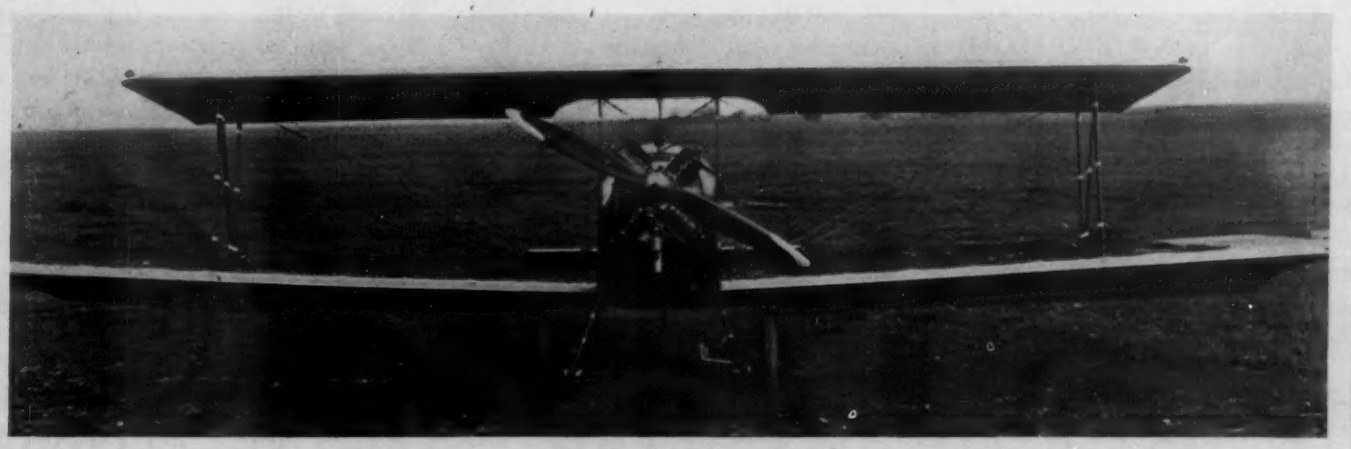


Health Education

(*Continued from page 168*)

ciations at its meeting in Toronto, Canada, last summer formally endorsed the development of organized and supervised programs of health education as desirable for all public schools in all countries. This movement is really improving the habits of living of the rising generation. What will it mean to industry? It will mean a generation of workers in shop, factory and office who can make a more intelligent adaptation to sedentary or factory life. "One's health is affected, not by what he knows but by what he does." More important than an improved knowledge in the rising generation is the fact that they are actually practicing better habits of living throughout school life. The school is taking its place solidly beside the home in contributing to the health of the child and is thereby contributing to its pupils a saner viewpoint toward health. In the experience of health education our boys and girls are proving to themselves that the way one lives affects the way he feels and what he can do. This program is making an unquestionable contribution to the better health of the next group of workers. It is doing what the industry cannot do — it is leading to a program of more healthful living during the sixteen hours when the worker is away from the plant. It is leading to more healthful homes and more healthful recreation. It is producing a health consciousness and also a sane attitude toward health, disease, the use of scientific medicine, public health administration, and the maintenance of industrial health conditions.

It may be that some day someone will develop in industry itself a program of positive health which will contribute to the health of workers as this program is contributing to the health of school children; but even if that is done, although it may be able to show a more immediate return in dollars and cents to the industries involved, it cannot make the contribution to health which the school program is making. The time to build sound bodies, sound attitudes, sound minds and sound knowledge is the period of youth, the period when all of these things are growing and taking shape. The welfare, the scale of living, and the economic prosperity of a country depend in large measure upon its industrial efficiency, upon its relative productive power per worker. The contribution of health education to working efficiency is not immediate. Today it is contributing to the health and happiness of millions of children. In the next decade it will begin to contribute to industry.

Experimental Mine

(*Continued from page 148*)

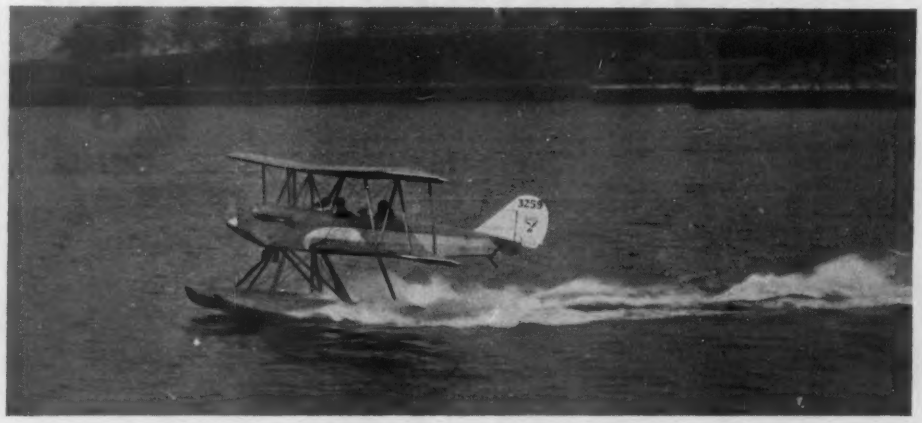
water. It has been found by experiment that water tends to agglomerate the dust and prevent the formation of a dust cloud. However, the wet dust of high-volatile bituminous coal is still explosive if a cloud of it is formed and violent gas explosions are capable of forming such clouds. Water can be used advantageously to prevent the dust from scattering during mining and transportation of the coal, but it has little value as an explosion preventive.

The best method of preventing coal-dust explosions is to mix inert dust with the coal dust. This method was first suggested by the late Sir William Garforth in England, and the process is commonly called rock-dusting in this

(*Continued on page 172*)

Edo

Float Equipment for Seaplanes



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TE-5

Experimental Mine

(*Continued from page 170*)

country. Fine inert dust, such as limestone, is distributed mechanically over all the surfaces of the mine passageways at the rate of 2 to 5 pounds per linear foot. The amount of rock dust required has been found to vary primarily with the composition and size of the dust. Two sizes of dust are commonly recognized. The first is fine float dust which settles from air on timbers or elevated ledges, and 70 to 90 per cent of which will pass a 200-mesh sieve. The second is the dust found on the floor or roadways throughout the mine and is much coarser. Dust is defined as material that will pass a 20-mesh sieve and is further graded according to the amount of dust passing a 200-mesh sieve. Dust taken from the floor of a mine will have 10 to 20 per cent of the material passing 200 mesh. This is less explosive than the finer dust taken from timbers and ledges.

It has been found that the explosibility of coal dust is in general greater as the proportion of volatile matter increases. Anthracites are not explosive. The amount of rock dust required to prevent propagation of an explosion increases steadily from semianthracites through semibituminous to high-volatile bituminous coals. Also, the explosibility of the dust is increased by the presence in the air of small amounts (1 or 2 per cent) of fire damp frequently found in operating mines, and additional rock dust must be used to offset it.

An explosion can be extinguished by concentrating a large quantity of rock dust in a container so that it is discharged into the air in the path of the flame. Such a device is called a rock-dust barrier and is intended for use only at points where it is impossible to rock-dust the mine properly.

Other Investigations

The experimental mine has been available for other studies than dust explosions. These can be mentioned only briefly. The chief of these has been a study of mine and tunnel ventilation. The transverse system of ventilation now in use in the Holland Tunnels between New York and Jersey City was tested and proved at the experimental mine before construction of the tunnel began. An elliptical race track was constructed in Nos. 1 to 3 rooms (see fig 2) and equipped with the transverse system of ventilation. Automobiles were operated in it for two-hour periods during which studies were made of the contamination of the tunnel atmosphere by the exhaust gases, the effect on the drivers and others present, and the determination of the smoke density and reduction of vision. Following this an extensive study of the friction of moving air on the surfaces of mine passageways and of the losses caused by obstructions such as cars, timbers, bends, and line and check brattices was made. Lately some tests of small auxiliary fans have been conducted.

Tests have also been made of the durability of brattice cloth, decay of timbers, strength of mine stoppings, storage of helium gas in underground chambers, use of the geophone, radio transmission underground for use at time of disasters, and methods and apparatus for fighting small mine fires. Such tests can usually be carried on only when the mine is not being used for coal-dust explosion tests, hence

(*Continued on page 174*)

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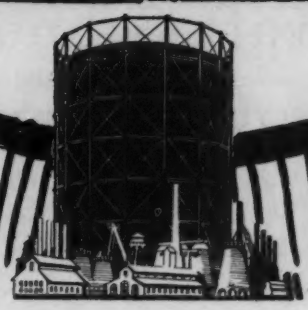

Experimental Mine

(*Continued from page 172*)

their number and scope has been somewhat limited.

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The Production of Electrolytic Iron is a development which has received considerable attention in recent years. The main objection was that the low intrinsic value of the iron did not warrant the expense of the process. However, several men have recognized the value of such a method of producing this metal, and as a result we now have the Cowper-Coles electrolytic iron process. The essentials are as follows: a cathode which rotates at a critical speed; ferrous sulphate; or a mixture of ferrous sulphate and ferrous chloride as the electrolyte, which is kept at the proper density by the addition of finely divided iron or iron oxide; and an anode or mandrel, previously coated with an intermediate plating of lead. This coating facilitates the removal of the product at the end of the run.

The great advantage of this process over the blast furnace is that a pure iron is produced which is entirely free from those elements which are so detrimental to the production of high-grade iron and steel.

Bell Telephone Laboratories

(*Continued from page 151*)

are employed in the production of this apparatus. They establish the design, establish the requirements and cooperate with the manufacturing department in the working out of the methods of manufacture.

To give an idea of what these small things mean in the way of dollars and cents over a period of years, we had occasion recently to review some of our bread and butter work, as we call it, of the past three or four years, work of which nobody had heard. All the spectacular things have, of course, been talked about; people hear about them and they are interested in them, but the day-by-day results of our detailed development work are not as spectacular and they are not as commonly known.

A list was made of these small things which had been put into production, modifications of designs or substitution of new designs of small parts over a period of three years, and it showed a total annual saving to the Bell System of roughly $12,000,000. That was just a spot check of these small things. Now that $12,000,000 saving is not only for this year but next year and all the rest of the years, as long as we use this type of equipment.

Another branch of our activities has to do with the production of so-called communication appliances not primarily for use in connection with the telephone system. As a result of researches and developments in the telephone field, there have been devised methods and apparatus which find application in other fields, and it has seemed desirable to make these methods and devices available in those fields where they will be of value. There is no particular commercial advantage to be derived but we feel it is a duty we have toward the public in general.

In connection with our research work on speech and audition, it has been necessary to develop a device for measuring the volume of speech and acuity of hearing. Out of this has grown a device known as the Audiometer which has found application in the medical profession. For the first time it is now possible to measure the acuity of hearing. The old method used by aurists was to strike a tuning fork and hold it at varying distances from the ear to determine the distance at which the sound could just be heard. The precision method can now take its place as a new tool which cannot help but be of great value to humanity.

With this, there has also gone forward the application of telephonic appliances for the aid of the hard of hearing. Devices of this sort are now available, and their design is based on a proper fundamental conception of the requirements of the case and involves the very latest developments in the communication art.

A similar type of instrument is the so-called electrical stethoscope which has been given publicity in the public press. It is now possible to detect heart murmurs and other chest sounds with a degree of precision that has heretofore been impossible. We are not only able to detect sounds that have previously been inaudible but it is also possible, by means of properly devised filter arrangements, to block out the sounds that we do not want to hear and to accentuate the sounds that we do want to hear. This work has been carried still further until now cases of typical normal and abnormal heart sounds have been recorded on phonograph records so that they are readily available for the instruction of students. To make such a plan practicable a special pick-up device had to be developed, as the ordinary commercial phonograph will not reproduce the low frequencies of the heart sounds.

This may serve to give a very general picture of the character of the work which is being carried on. A few remarks regarding our methods of operation and our ideas in general with regard to the conduct of this type of work may not be out of place.

The outstanding feature of the Bell

(*Continued on page 176*)

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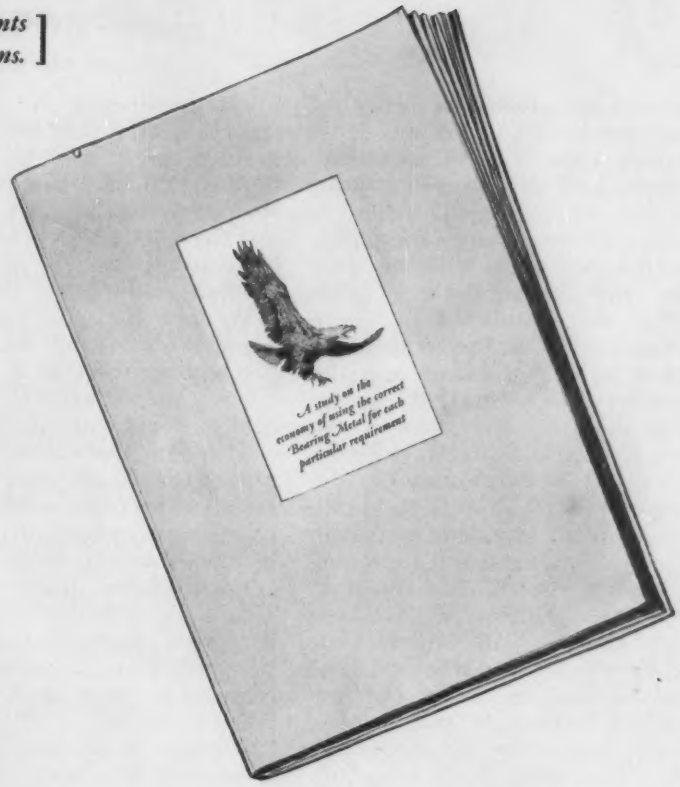

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Bell Telephone Laboratories

(*Continued from page 174*)

Telephone Laboratories is probably the group method of operating. This is something quite new to the conduct of research and development work. Not so very long ago, experimenters were lone workers. They each had a room with a lock on it, with only one key, and they carried the key. This method is still employed in many places, but because of the tremendous complexity of our problems and the large number of problems that must be carried on simultaneously, no one man or no small group of men working by themselves could accomplish the desired results. It is beyond the capacity of an individual. Imagine one man trying to develop a machine switching system within his own life time! It simply cannot be done. It has been necessary therefore to evolve some method by which these results can be obtained by making use of the personnel which is available, and we have, as a result, come to the so-called group method. This is nothing more nor less than a plan for dividing the problem, no matter how complex, into its essential elements and assigning each of these problems to the individual or group of workers who is best equipped to carry them out. It may be a chemical problem, it may be a metallurgical problem or it may be a mechanical problem. In each case it is assigned to chemists, metallurgists, or mechanics and the work on their respective problems results in the solution of the problem as a whole.

We have had our troubles in working out this scheme. In the first place it might appear that it would tend to destroy the initiative of the individual, that it would make it difficult to properly assign the credit and give the reward to the individual worker. These are all problems of administration that have had to be worked out. First of all it is necessary to establish the fact in the individuals' minds that their best results are attained through coöperation with others; that in the long run the individual can accomplish more by coöperation with his fellows than by going it alone.

Another somewhat unique characteristic of this work is that contrary to the case of most lines of industrial work, we are engaged in the development of devices and systems for use rather than for sale. The same engineering considerations, the same seeking after facts and truth, are applied to the use of the device as is applied to its original development and manufacture. This seems to be an ideal set-up from the standpoint of the engineer.

We are not confronted by the many artificial considerations which are involved in a business where apparatus or systems are being designed and manufactured to sell in competition with others merely as a commercial transaction. Oftentimes we make a choice of devices where the more expensive device, so far as first cost is concerned, is employed rather than the cheaper; the sole criterion being the overall cost of that device expressed in terms of service over a period of years.

This is a somewhat unique situation and cannot help but give greater scope to the activities of the engineer. He is not handicapped, not restricted, by considerations other than those of an engineering character.

In concluding it might be well to say something about the kind of men required for carrying on the kinds of work which have just been described. They are the same kind of men that are required in every other worthwhile

(*Continued on page 178*)

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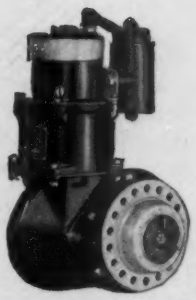

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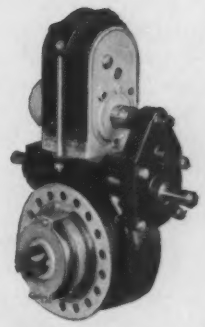

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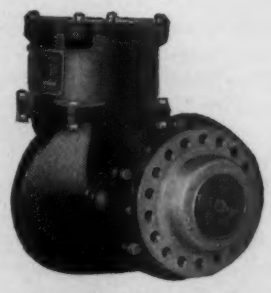
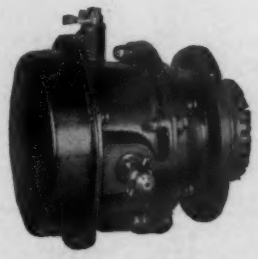


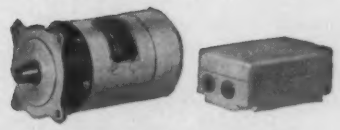
Eclipse Series 7 Hand Inertia Starter. Vertical type, adapted for V-type or radial engines up to 2500 cubic inches.

Eclipse Series 6 Combination Hand and Electric Inertia Starter for radial engines up to 1350 cubic inches; Series 11 Combination Hand and Electric Inertia Starter for radial engines up to 2500 cubic inches. Concentric type, with magnetic switch.

Eclipse Direct Cranking Combination Hand and Electric Starter, adapted for application on engines up to 2000 cubic inches.



Eclipse Series 6 Hand Inertia Starter. Concentric type, particularly adapted for radial engines up to 1350 cubic inches. Series 11 Hand Inertia Starter for radial engines up to 2500 cubic inches.



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ECLIPSE

AVIATION ENGINE STARTERS AND GENERATORS

Bell Laboratories

(*Continued from page 176*)

task. We use mechanical engineers, electrical engineers, chemists, metallurgists, etc. All of them must possess certain characteristics in common. That they must have a certain training in fundamentals goes without saying. They must, of course, have a certain amount of intellectual curiosity and all the other normal attributes of intelligent human beings, but in these modern days they must possess something more than these. They must possess the faculty of working in coöperation with their fellow men on their common problems. If they do not have that faculty they are deficient in an important respect. This is a tremendously large country and we do things in a big way. The only means by which things can be done in a big way is through coöperative effort. We therefore must have coöperators as well as engineers.

Simplified Practice

(*Continued from page 156*)

Department's publication, "Simplified Practice, What It Is and What It Offers."

Five years' experience has shown that the success of a simplification project depends on four fundamental steps. First, a comprehensive survey of the demand for existing variety; second, a sound and conservative elimination of non-essential items, with proper consideration of the needs of all groups affected; third, enlisting the active support of producers, distributors and consumers; and, fourth, maintaining interest and adherence by keeping the program abreast of current practice through periodic revision.

The Division of Simplified Practice is convinced that its work in connection with steps one and four is best carried on through committees selected by the industry. These act as liaison agencies and perform the necessary duties which precede and follow a general conference.

At the close of its session the general conference appoints a permanent standing committee, composed of not more than three representatives from each phase of the industry; for example, producers, distributors, and consumers.

The proper functioning of the committee requires that its members be able to attend in person, meetings held at some central place. They must also be prepared to devote the necessary time and to accept such assignments and responsibilities as may be found requisite to the success of the program.

Because the Department, in no case, assumes the prerogative of taking final action in connection with a simplified practice recommendation, it is essential that there be some avenue through which the industry can be promptly consulted and can, in turn, make known its wishes. This function is best performed by a representative standing committee. For this reason the chairman, in accepting his appointment, places his services and those of his committee at the disposal of the Division of Simplified Practice for the prompt and careful consideration of all questions which may arise when the program is put into actual use.

A committee that quickly and accurately reflects the wishes of the majority of its industry and, through its chairman, promptly disposes of matters referred to it is a practical insurance against any serious difficulty in the adoption of Simplified Practice.

The standing committee must recognize that the Department of Commerce has no "police powers" to compel the acceptors to adhere strictly to the letter of the recommendation. Unanimous adoption by the general conference indicates a recognition of the benefits inherent in simplification. If this fact is properly emphasized, the acceptors should be equally willing to follow the program in all cases where it is applicable.

While the recommendation is in effect, the standing committee is to receive all information showing departures, and to apply such corrective measures as appear to be in the best interest of all concerned.

Figure I shows the important contribution which the standing committee makes to the success of a simplification project.

Obviously, standards are only valuable insofar as they are followed. It is in maintaining adherence that the Department of Commerce is able to render its most effective service. Periodic resurveys and revision meetings encourage continued interest in the project and insure such changes as will keep it in accordance with the best current practices.

There are now more than eighty Simplified Practice Recommendations officially in effect. Table I shows the degree of adherence being accorded those which were re-surveyed during 1927.

The figures shown in the last column of the table indicate the proportion of the total annual output of all accepting producers which conformed with the Simplified Practice Recommendation.

Factual surveys of the benefits of Simplified Practice have brought estimates of savings in material, time, labor, and money totaling approximately six hundred millions of dollars a year. The figures, by industries are: Paving brick, $1,000,000; sheet steel, $2,400,000; steel reinforcing bars, $4,500,000; warehouse forms, $5,000,000 range boilers, $5,500,000; inquiry, purchase orders, and invoice forms, $15,000,000 and lumber, $200,000,000.

In the past five years a great deal has been written about the benefits of Simplified Practice to manufacturers, distributors, and consumers. Often these benefits have been expressed in such general terms as: reduced capital investment in raw materials, semi-finished stock, and storage space; reduced clerical overhead; increased turnover; better service; more concentrated sales effort, etc. Arguments of this character are much more easily presented than concrete dollars and cents savings. Fully half of the industries which have adopted Simplified Practice found it difficult to interpret their benefits in terms of money, because of the existence of other controlling factors. Some individual ac-

(*Continued on page 180*)

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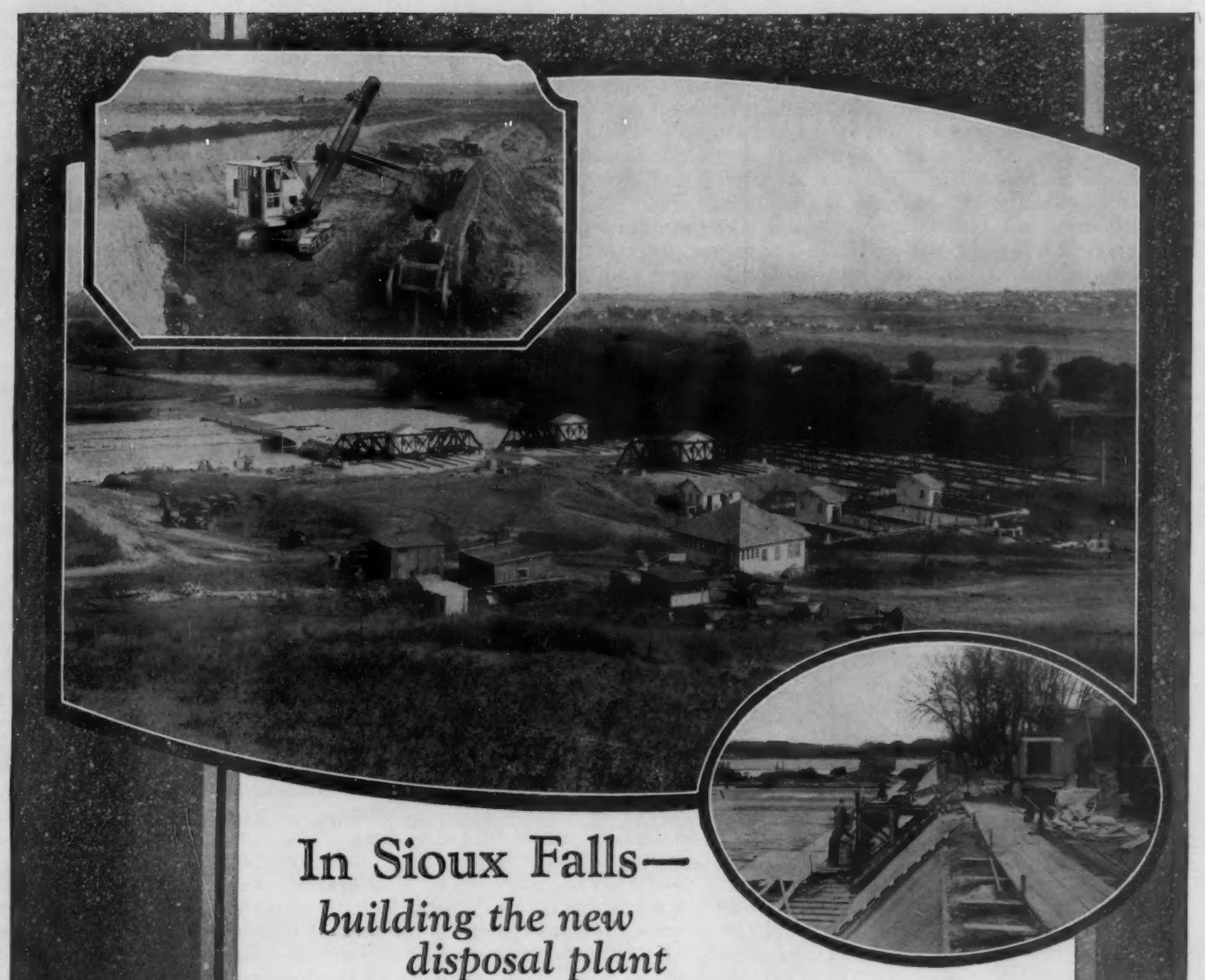

In Sioux Falls—
building the new disposal plant

WHEREVER you find construction work in progress, be it an engineering triumph or a lesser achievement, it is quite probable you will find Koehring Heavy Duty equipment.

One of these typical projects is the disposal plant at Sioux Falls, South Dakota, where a Koehring No. 301 Heavy Duty Shovel did the excavation work and two Koehring Heavy Duty Mixers produced the re-mixed concrete.

The large view gives a comprehensive idea of the entire plant while the smaller illustration in the upper left shows the Heavy Duty Shovel excavating part of the 100,000 yards which were moved on this job. The Koehring mixers, shown in the oval inset, turned approximately sixty carloads of cement, together with proportionate amounts of sand and crushed stone, into dominant strength concrete.

In thousands of places the story of Koehring equipped jobs is the same as that in Sioux Falls—Koehring dependability wins.

The revised edition of "Concrete—Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, is now ready for distribution. To engineering students, faculty members and others interested we shall gladly send a copy on request.

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KOEHRING HEAVY DUTY

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Simplified Practice

(*Continued from page 178*)

cepters have very definite economies to report. For example: One manufacturer of metal lath says that his inventory has been reduced $140,000; while another manufacturer of eaves trough and conductor pipe reports a $30,000 reduction in his inventory.

In this article I have endeavored to show that Simplified Practice has proved its practical value in many widely divergent industries. It is only fair to assume that similar results will follow its application in other fields. Emphasis has been laid on the Department's policy, approved by industry, not to undertake the development of a recommendation except when requested to do so by one or more of the groups interested.

The following quotation from "Waste in Industry" is as timely today as it was seven years ago:

"Engineers come in contact with and influence every activity in industry and as a body possess an intimate and peculiar understanding of intricate industrial problems. They are in a position to render disinterested service, and their peculiar responsibility is to give expert judgment wherever engineering training and technical skill are needed to reach a just decision.

It is peculiarly the duty of the engineers to use their influence individually and collectively to eliminate waste in industry."

Tie Welding

(*Continued from page 155*)

the ends of the rail by hand. The tie is easily rotated in the machine, so that the automatic welding heads can operate first on one edge of the tie plate and then on the other. Upon completing the weld, the tie passes along the conveyor and another pair of rails enter the machine. The welding motor generator and resistors may be used for general welding when not otherwise employed.

In addition to the general application of steel ties, it should be noted that they are particularly applicable to certain installations, such as sections of track where cinders are dumped and the wooden ties consequently are subjected to burning and high rates of deterioration.

To Mr. William Dalton belongs the credit for the solution of many of the important problems in connection with the manufacture of railroad ties described in this article. Mr. Dalton was closely in touch with railroad problems prior to his connection with the Manufacturing General Department of the General Electric Company and his cooperation with the designers of automatic welding machinery has resulted in a practical method of producing steel railroad ties. Also to Mr. Dalton belongs the entire credit for the ingenious method of fastening the rail to the steel tie.

The World's Largest Vehicular Tunnel is soon to be completed between Oakland and Alameda, California. Interest in the tunnel is due mainly to the novelty and difficulty of the methods of construction and its unprecedented diameter. The largest existing subaqueous work of this kind is the Holland Tunnel below the Hudson River, whose diameter is 29½ feet. The diameter of the California tunnel is 37 feet, the walls being 30 inches in thickness and built of concrete heavily reinforced with steel.

In cross section, both tunnels are similar, each consisting of three separate longitudinal compartments, the lower forming a fresh-air duct, the upper a foul-air duct, and the center a roadway which measures 24 feet from curb to curb. The total length of the tunnel including approaches is 4,436 feet.

Twelve concrete segments, 203 feet long and weighing 5,400 tons apiece, were used in the construction. The segments were built in dry dock, then closed at both ends by a steel and timber bulkhead, floated, and towed to the site where they were sunk in a deep trench which had been dredged across the estuary. Each segment was loaded with sand ballast so as to draw 37 feet. When towed to the site, water ballast was added to lower it into place. The segments were joined by pouring a ring of concrete. Although the diving operations were carried on at a depth of 100 feet, the actual sinking and setting of each segment was usually accomplished in less than two hours.

In dredging the great trench, the upper material to a depth of 35 feet was removed by a suction dredge, and the remaining material by a clam shell dredge, a total of some 850,000 cubic yards being thus removed. A bed of sand was laid throughout the greater part of the trench where the underlying material was firm, but at the Alameda end the tube is supported for 400 feet on piling four feet thick and 65 feet wide, the piling being in rows, transverse to the axis of the tube.

Its performance will offer a splendid comparison of the construction methods with the more expensive one followed in building the Holland Tunnel.

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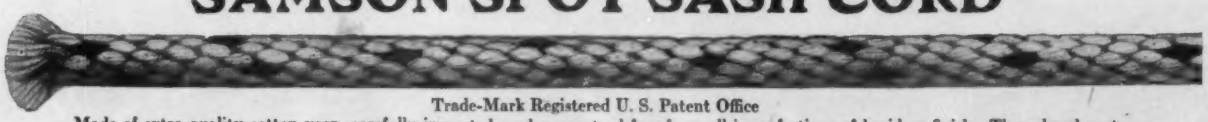

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Aerial Photography

(*Continued from page 145*)

be necessary. In Figure 1 it was shown that ground relief caused a displacement of images, but there is no method of determining the amount of relief from the displacement unless the true distance from C to A or B is measured on the ground. But if *two overlapping* pictures are used they will contain within themselves sufficient information for the determination of the heights of the various points in the zone of overlap. In Figure 3 it will be noticed that the distance on the picture is not the same on plate 2 as on plate 1. The difference between the two photographed distances is due to "parallax," and if the elevation *h* is known the parallax may be computed and vice versa. In order to correct the pair of plates the elevations of a few salient points are obtained by the usual ground methods and the parallaxes for these points are computed. These computed parallaxes are then compared with the actual measured values on the pair under consideration. The difference between the calculated and the actual values is due to tilt, (it will be remembered that in Figure 2 tilt caused a displacement of the images). From a study of the differences between the actual and calculated parallaxes it is possible to determine both the direction and the amount of tilt in the two plates. When this has been accomplished the plates are reprojected through the proper angles so that the new images are identical with the ones that would have been taken from the same viewpoints if the lens axes had been vertical at the instants of exposure.

The corrected plates are now ready for contouring. This is done on a stereoscope which is similar in principle to the common hand stereoscope with which every one is familiar, but which is radically different in construction, being designed to give a much more pronounced stereoscopic effect, to make this effect quantitative and exact, and to measure parallax to the thousandth of an inch. The actual contouring is done by drawing a line through all the points having the parallax value of the contour in question. This means that the elevation of every point through which the line passes has been accurately measured. It is easily seen why contours drawn on these stereoscopes have more accuracy and expression than contours sketched in the field.

The contoured plates as they come from the stereoscope are still far from being maps because each contour is at a distinctive scale. A specially devised machine is used to transform these contours and all other information on the pictures to the desired uniform scale of the final map. After passing through these machines there results a series of small maps, each covering the area common to a single pair of plates. These small maps are now assembled into the final map covering the full area. Blueprints and tracings are then made from this map in the usual way.

Intercommunication Between Aircraft

(*Continued from page 143*)

the panels, which are usually of rather large dimensions, make it possible to send complete messages. During a clear day, the receiver generally has no trouble in distinguishing the signs, and with good illumination, ground panels have been used very successfully at night. Readiness to receive signals as well as the confirmation of their reception is indicated by aircraft either by a manoeuvre or by a simple prearranged sign. In connection with ground panel signaling, one of the most secure methods of answering yet discovered is employed. This consists in dropping written messages provided with long streamers on to selected "dropping grounds." The simplicity of the entire procedure, as well as its effectiveness during day or night, has made this a favorite scheme of the American and British armies.

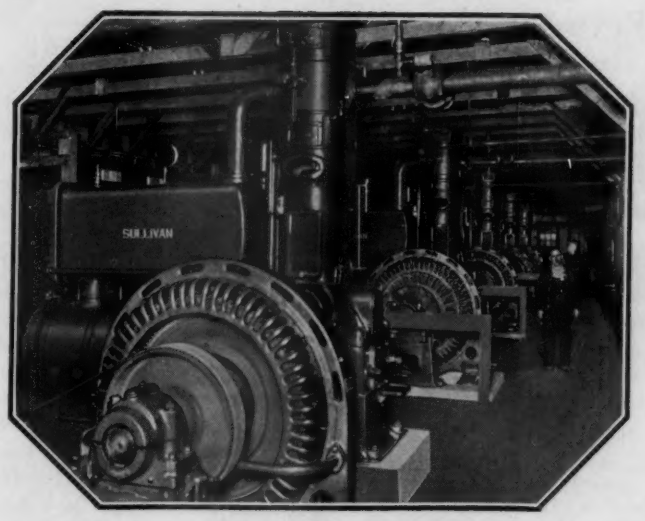
Signaling by smoke was one of the earliest means of transmitting intelligence used by man. The Indians of America were extremely proficient in sending smoke messages, often over long distances and with astonishing rapidity. Modern man has developed the primitive man's smoke signal, until he is now able to write a message in the sky that can be clearly read by anyone who cares to look heavenward. Sky-writing is today a common practise, and one may frequently see advertisements written in white smoke by a tiny speck moving about in the air. Two methods are commonly employed, one invented by the English and the other by Americans. It is not generally known what chemicals the English use. With the feeling, perhaps, that divulging this mystery would diminish the majesty of things, our friends have continued to keep their secret. The American method involves the use of ordinary crankcase oil. This oil is pumped into the exhaust manifold well behind the exhaust ports of the engine, where it quickly volatilizes and is led back through tubes to the under side of the tail surfaces and there ejected into air. The great advantage of this method is that the smoke is visible at a great distance. The writing, moreover, may be performed in either Latin script or code, and during a clear night with searchlights playing upon him the sky writer may perform in the air to his heart's content.

Even more impressive are the pyrotechnic flares. The Very light, magnesium flares and extensive firework displays have been used to convey messages. As an indication of the night flier's intention of landing and to facilitate his alighting safely, he will often fire electrically ignited magnesium wing tip flares or release a magnesium light attached to a parachute. A fire hazard is, of course, involved, but when pistols are used and the surfaces on which the burning phenomena take place are carefully protected, there is comparatively little danger. Indeed, even if flares are perilous, it would be most cruel not to allow the aviator to satisfy his romantic soul, especially on a starry night, when the setting is so perfect. We ought to take into account here, the type of humanity we are dealing with. Certainly the flying man is different.

Most night signaling from the ground to aircraft is carried out by means of "flashing," by which is meant the exposure and eclipse of a single light for short and long periods of time, representing dots and dashes composing the required symbol. The dots and dashes can be made mechanically by an obscuring arrangement, or by electro-mechanical means where magnets do the work, or by simply switching on and off specially manufactured electric lamps. For long distances, a high-power electric arc light may be used on the flashing system. Clouds are often of advantage to this method for it has been found by experiment in the British Navy that when a convenient cloud is available, the reflection of the beam may be read at a distance of nearly forty miles. The use of neon lights, moreover, makes this system effective even in dense fogs. Neon lights being of a vivid orange color, can be easily distinguished in the air, and have already been put into service in some of the European airports, particularly in England and Germany.

It is certainly of great importance to the aviator to be properly informed from the ground as to his exact vertical position when he wishes to land his ship at night. Because of the difficulty of judging distance from the air when it is dark, the Germans have invented an ingenious scheme which eliminates much of the danger of night landings. Two concentric rings, one of about ten feet in diameter and the other of a slightly smaller dimension, are mounted

(*Continued on page 184*)



Five of the eleven Sullivan Angle Compound Compressors supplying air power for building the Great Northern Cascade Tunnel, America's Longest Railway Tunnel.

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Intercommunication Between Aircraft

(*Continued from page 182*)

on a truck in planes parallel to each other and vertical with respect to the ground. These rings are illuminated by electric lamps spaced equally along the circumferences. The truck is moved so that the rings are always facing the direction of the wind, which may be ascertained by the pilot by remarking the position of an illuminated wind cone or an electrically lighted arrow. The pilot flying against the wind, constantly manoeuvres to make the rings appear concentric to him. When they are concentric he is very near the ground. He then gently settles down, thus completing the landing operation. Much success has attended this method and with the neon tubes soon to be used in connection with it, landing in a fog, even in the daytime, may not be attended with so many fatalities as have hitherto been suffered.

More elaborate lighting schemes, such as beacons and flood lights, are used at the larger airports. Even the point on the ground where the pilot ought to touch his wheels for a good landing is indicated. Another plan involves the use of a trap door which opens up from the ground and allows the wind to roll illuminated dense white smoke along the surface of the field. Progress along these lines is everywhere in evidence, which means that night flying, because of good communication from the ground to the aeroplane, has made night landing no more difficult than landing by day.

Quite apart from signaling methods, messages can be "handed over" mechanically, so to speak, in midair. When it is considered that men have changed from one aeroplane to another in full flight and have refuelled air mail carriers en route, the exchange of written messages in this manner becomes quite ordinary. Some success has also attended the snatching of mail from between two poles where it is suspended. In the developed state, therefore, this procedure promises to be one of the best for intercommunication between aircraft, and aircraft and the ground. It should be especially valuable to newspaper syndicates and military authorities wishing rapid delivery of photographs from various localities to a single or several places. An express aeroplane, making a circuit of designated cities, could pick up material from "feeder ships" and so include a wide area. Dropping information with the parachute and exchanging intelligence with the "feeder ships," in this manner, ought, with development, to prove a very swift and efficient scheme.

It would be impossible to leave the subject without mentioning the classic Noah method of sending forth pigeons, not to gather, but rather to deliver messages. These little birds have done heroic work for us ever since the flood and it would be entirely unfair not to give them the meritorious praise they deserve. But it is time we stopped molesting these happy creatures. We ought to allow them unrestrained freedom and look rather to the enslavement of the laws of nature for our communications.

Now that we have listed and explained (not exhaustively, to be sure) the different methods of intercommunication, we must examine the needs for, as well as the past and future development of interchange of intelligence between aircraft, and aircraft and the ground. The need for it, though not especially urgent to the dare devil who loves the excitement of danger, is nevertheless quite imperative when one considers the commercial aspects of the question. In order to transport passengers and mail with safety, there must be close communication between aircraft and the ground at all times. The pilot must be sure of the course he is flying, and painted signs as well as illuminated characters are welcome aids.

Moreover, it may be necessary to communicate with the pilot from the ground to avoid some calamity. Take the instance, for example, of the aeroplane which, in getting off the ground, lost an insecurely fastened landing wheel. The information was soon communicated to the pilot by another who flew beside him with the message written on the side of the aeroplane. Being informed of the situation, the pilot proceeded to make a "one wheel" landing without any serious consequences either to himself or to his passengers. Incidents of this sort certainly emphasize the need for adequate communication at all times.

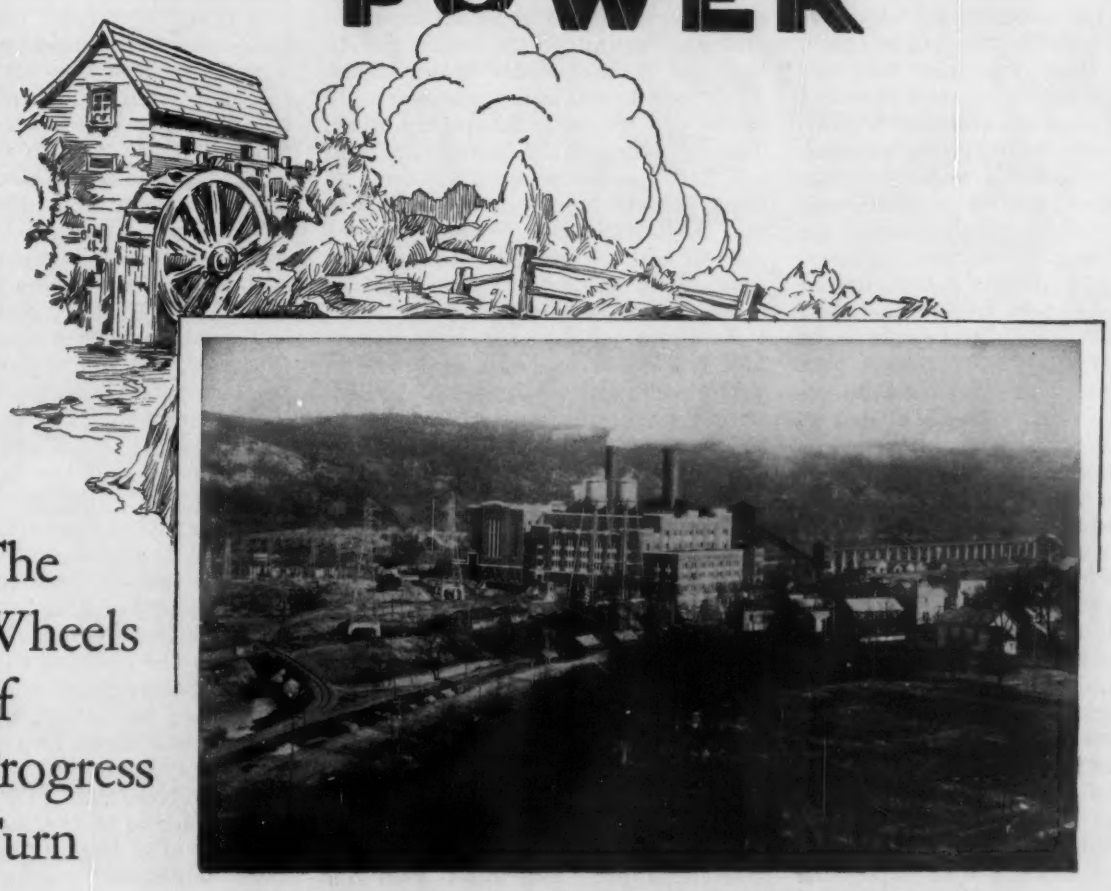
In examining the past, we become more and more impressed that without experience, nothing can be known with certainty. Sirens and semaphores, discs, flags and even (in Simon the Magician's day) a shimmering scarf stained with the red blood of a green dragon killed in the light of a waning moon, were all used before their limitations were known. Difficulties in overcoming the vicissitudes of the weather have been encountered. The four winds, though nothing to the modern aeroplane in the air, have shown that they must be respectfully regarded when the airman wishes to alight on his terrestrial objective. The fog has so artfully hidden the ground, that the pilot, thinking himself safely aloft, has often crashed to his death on some unseen obstruction. It is this experience, so dearly paid for, that will enable us to choose better for the future.

Not by divination by the stars but rather by reading the history of the past are we convinced that the ideal system of the future for transmitting intelligence, apart from those systems depending upon a single sign, will have to incorporate the use of the international code of signals. It is the best universal dictionary in existence. By its means any question may be asked and answered. With the ever-increasing speed of aircraft and the reliability of the motors in all conditions of weather, communication at great distance between the aircraft and the ground will be of less importance. This will be especially so when intermediate landing fields are provided. The use of neon in both foggy days and at night will very likely solve to a great degree the problem of communicating landing intelligence to the pilot. As a matter of fact, the concentric landing rings described herein seem to be a satisfactory solution, having the advantage of being comparatively small and mobile so that they may be stationed at intermediate landing fields to be used in case of emergency. As for the weather conditions along established routes, reports can very easily be flashed by beacons or neon lights so that the pilot may be completely informed as to what course he ought to follow at night. During the day, however, it will be necessary for him to depend on some existing or developed electrical means, or upon visual signaling such as the ground panel method.

As for interplane communication, except for the interchange of intelligence at short range, none of the methods described are likely to survive when long distances are involved. The necessity for long distance communication between aircraft, will not assume any great importance until transoceanic flight is put on a commercial basis. At that time, the methods in use by ships adapted to aircraft will be put into service.

In conclusion, we venture to say with full confidence that, with the increase in travel by air, made more secure by intercommunication between aircraft, and between aircraft and the ground, we shall begin to regard our distant fellow men as close neighbors. When this visionary dream is accomplished, we shall then begin to live in the true sense of the word.

POWER



The Wheels of Progress Turn

PHILO POWER STATION, PHILO, OHIO, CONSTRUCTED BY THE FOUNDATION COMPANY

When our forefathers built their primitive water wheels to use the power of running water, little did they dream of the super-power plants to be developed later. Nor could the early scientists, who first experimented with electricity, have conceived of the extensive uses to which it could be put.

In this age of power its advancement has been more and more due to the public which uses it, and which owns a large part of the securities issued for the erection and maintenance of the generating plants.

New uses and new users of power are tremendously increasing the demand for the enlargement of existing stations, and the construction of new ones, both steam and hydro-electric.

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BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES

Aeronautics in Technical Schools

(*Continued from page 135*)

future. For the greatest good, the efforts of the technical school and its staff should be concentrated upon giving the best possible training to those, and only to those, who have both the will and the capacity to assimilate and grasp the application of scientific principle necessarily intensively presented.

The very essence of scientific progress is research, and no student who hopes ultimately to take a place in the vanguard of new development can consider that his education is complete or that his instructors have done their duty by him unless he has been brought with some intimacy into contact with current research activity and its results during his collegiate career. Knowledge of scientific fact never gains such dramatic force as when one is privileged to share in the first dawning upon a human mind of some bit of information, some confirmation or contradiction of hypothesis, that is entirely new. The lecturer capable of inspiring the student, who in his own intellect possesses the spark of divine fire, is no mere histrionic performer rendering a platform performance by rote. Inspiration to men of that type, and they are the most important men with whom education has to deal, proceeds from the teacher's own intimate day-by-day relationship with the raw materials of experiment and hypothesis out of which are fashioned finished truths, and finished scientific truths, in turn, no less surely than aluminum, spruce, and alloy steel, are the raw materials with which the aeronautical engineer, like others who apply natural science to the service of man, has to deal.

Research and education should be driven in parallel, with neither one allowed to get far away from the other. In supporting the aeronautical course at the Institute by sending students there, the Navy and Army have both been training men for their own technical services, and helping both directly and indirectly to stimulate the evolution of new contributions to aeronautical knowledge. In encouraging the continued operation of the Institute's aeronautical laboratories by furnishing work to be done there and bearing the costs, the Army Air Corps has given indirect, but none the less valuable stimulus to the educational activity in the aeronautical field. One of the most fortunate of results from the occupation of the new building will be the joining of laboratories, drafting-rooms, and classrooms under one roof. The departments detailing officers to the study of airplane design and other aeronautical subjects at the Institute will view with great approbation, which should be shared by all the individual students, this permanent housing of aerodynamic and structural laboratories in immediate contiguity to the halls of the students' major labors. The students will be brought more into closer contact with laboratory work. The members of the instructing staff will find it easier than ever in the past to participate directly in research work, and by participation in research they enliven and refresh their own outlook upon their subject, to the profit of those whom they instruct.

Aeronautical research is a worthy and full career in itself. It is one in which some few graduates of the Institute have shone greatly, although fewer than might be wished have espoused it as their central activity. For the majority of students at the Institute and other similar schools in the future, however, as for a perhaps regrettably great majority in the past, the activities of the laboratory are bound to constitute a sphere of minor personal interest after graduation. To a study of scientific principles and of the means by which they are discovered and the limits of their applicability probed, the average student in aeronautical engineering must both by his own desire and for his own good add much time devoted to highly practical considerations. He must gain the ability not merely to conceive in the abstract but to transfer his conceptions to paper. He must know how a vast portfolio of drawings is metamorphosed into a finished airplane, and how the airplane is taken from the factory to the field and operated there.

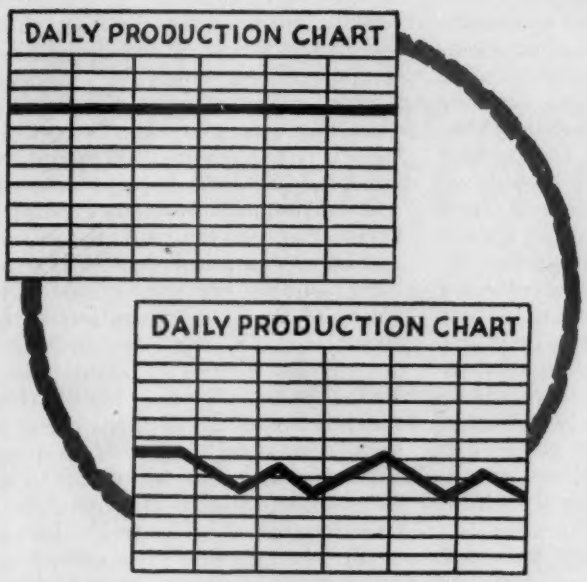
It is the fate of most students of engineering, whether a fortunate fate or otherwise it would perhaps be incautious to say, to gain their acquaintance with the finished material objects that result from the application of the engineer's art in a manner analytic rather than synthetic. They learn first to know the finished machine and its functioning, then to break it down and study its parts and their purposes, and, finally, to examine what had to happen before even the metal was melted for the casting, the sand tamped around the pattern, or the pattern made. The officer of Navy or Army, already qualified as an aviator before being detailed to study aeronautical engineering, must approach the airplane in somewhat the same way. The civilian undergraduate student of aeronautics, dealing as he does with a mechanism of which the actual operation does not yet fall within the scope of normal daily experience of the average youth, can proceed in the opposite manner. He can follow the course of evolution up to the finished product directly, rather than in reverse. He can start with aerodynamic and structural theory, proceed to the design of the individual parts of a plane, see how they are fabricated in the shop from the drawings, learn of the assembly of the elements into a finished whole, and so pass finally to what happens when the machine has left the factory and taken to the air.

The student who combines the merest modicum of imagination with an enthusiasm for aviation which has led him to wish to study its technical side, will want to have a share in all these processes, and will be unwilling to confine his contact with them to the pages of any one text. The properly organized technical school will give him the opportunity, and the trustees of the Guggenheim Fund are enabling the Institute and various other institutions of technical education to do so.

Wind tunnels and structural laboratories permit him to make contact with the development of first principles. In the drafting room he applies the laboratory results and the practical experience to design, and learns for himself how ideas "without form and void" may finally be reduced to neatly docketed blueprints. The natural progress thence is to the shop and to the building of at least a part of what has been laboriously designed, and the Institute has facilities permitting of the fabrication of almost any airplane part from the raw material and the drawings. Assembly of the elements so made into a completed structure is an obvious next step, and in the new aeronautical building itself there is provision for the setting up, rigging, and subsequent testing to destruction, of airplanes. The entire life history of an airplane, from the making of a model of a single wing for testing in the wind tunnel, up through the final collapse of the wings of the full-sized machine under the load of bags of shot or lead bars placed upon them as a structural test, can be enacted upon the Institute's grounds, and the students can and should have a share in every step of the process.

The one important activity for which the Institute's own facilities do not allow, and the real ultimate end of all aeronautical undertakings, is flying. It should not be overlooked in dealing with the training of technical men, for even though there are many aeronautical engineers of the first order of competence who have had no aerial experience as pilots and but little as passengers, there is not one who would not be the better for a personal acquaintance with the pilot's work, and

(*Continued on page 188*)



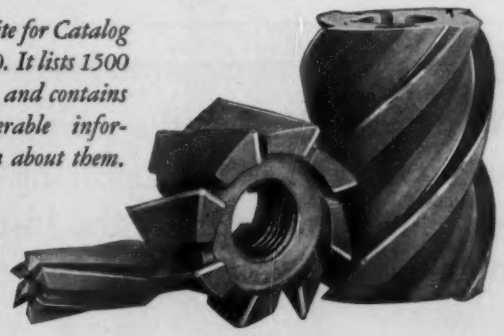
CUTTERS ALONE CAN MAKE THIS DIFFERENCE

THE first chart illustrates a healthy production. The second shows a production that is suffering with "sinking spells."

Milling Cutters alone can make this much difference on the same machine. When inferior, poorly designed cutters are used, they become dull quickly, power is wasted in nursing them along, and production suffers.

As the result of years of experience, the Brown & Sharpe Cutter Department has developed cutters that stay sharp for long periods between sharpenings, save power, and give a steady high production such as that shown in the first chart.

Write for Catalog No. 30. It lists 1500 cutters and contains considerable information about them.



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Importance of the "back-up"

A sign of a well-coached baseball team is the thoroughness with which its players back up each other in fielding. In this way, extra bases are saved—runs kept down.

Engineering products, too, should be "backed-up." And in the case of Jenkins Valves this backing-up takes a very concrete form—in the Jenkins Fair Offer, which reads now as it has for years:

If you will put a Jenkins Valve on the worst place you can find, where you cannot keep other valves tight, and if it is not perfectly tight or does not hold steam, oils, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.

Fig. 370
Jenkins Standard Bronze Gate Valve, Screwed.

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Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

Aeronautics in Technical Schools

(*Continued from page 186*)

for keeping himself conversant with the art by reasonably frequent practice as a pilot if his physical and other limitations permit, but in any event as a frequent passenger.

On that point young men need no urging. Their desire for personal participation in aviation is widespread, and they seek every means of gratifying it. To facilitate their accomplishment of their desire and at the same time to insure conditions of minimum hazard is a proper care of the collegiate authorities. It would, indeed, be well that at least an hour or two of flying as a passenger, in the course of which time varied maneuvers would be performed and the flying characteristics of the airplane fully displayed, should be made a requisite for every student taking aeronautical work of collegiate grade. Some, whether or not they care to devote themselves to the study of aeronautical science, will take to aviation through the medium of the flying club. Groups bent upon the purchase and operation of airplanes are breaking out everywhere in the colleges, as yet another symptom of current aeronautical enthusiasm, and with special attention to preparations for the forthcoming inter-collegiate competition for the Loening trophy. There are many, however, who lack the means to purchase their own airplane; who, because of inability to qualify as pilots at their own expense or for some other reason, cannot enroll as active flying members of flying clubs, and who are yet eager to get into the air. To them if they are physically and otherwise qualified, as well as to others subject to no stringent limitations, the departments of the Government charged with maintaining the armed services, engaged in building up a reserve force for the national defense hold out a helping hand.

Both Navy and Army maintain aerial reserves, and both offer special inducements to the college man. By enrolling either with a naval Reserve Unit or with an Air Corps Unit of the Reserve Officers Training Corps, he puts himself in line for piloting instruction far more extensive, thorough, and varied than he would be likely to obtain in any privately run flying school. It is a training which the prospective worker in the aeronautical field, and especially one who expects to devote himself to the commercial operation of aircraft, may well be glad to secure. The harmonious relations existing between the Government departments and the leading universities and technical schools are symbolized in the action of the Institute in setting up a special course for the preliminary ground instruction of candidates for Naval Reserve flying. Installation in the new building will offer greater freedom in the carrying on of that work. Its value, like that of all other aeronautical activities at the Institute, will be enhanced. Thanks to the initiative of the Institute and a few other leading institutions of similar type, to the far-sighted philanthropy of Mr. Guggenheim, and to the coöperation of the Government departments and of private aeronautical interest, we may feel assured that at the end of another decade a considerable group of young men, their native abilities and enthusiasm reënforced and guided by a specialized technical training of the highest order, will be making steady and rapid progress towards positions of leadership in the aircraft industry and in aerial commerce.

Pulverized Coal was used, during the early part of this year, as fuel on the steamship *Mercer*, and the trial trip proved to be highly successful. The *Mercer* is a 9,500-ton ship equipped with a 2,500-horse-power turbine. This boat had formerly been an oil burner and was chosen as the trial boat because she has twenty-two sister ships of both the oil and coal burning type with which comparisons could be made.

STUDENT INSTRUCTION *PASSENGER FLIGHTS*

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AERIAL PHOTOGRAPHY *JOY HOPS*

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To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are also offered. Special Research Laboratories of Physical Chemistry, Organic Chemistry, Applied Chemistry and Science have been established.

Correspondence should be addressed to the Institute of Technology.

PUBLICATIONS

Catalogue: Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

Any of the above named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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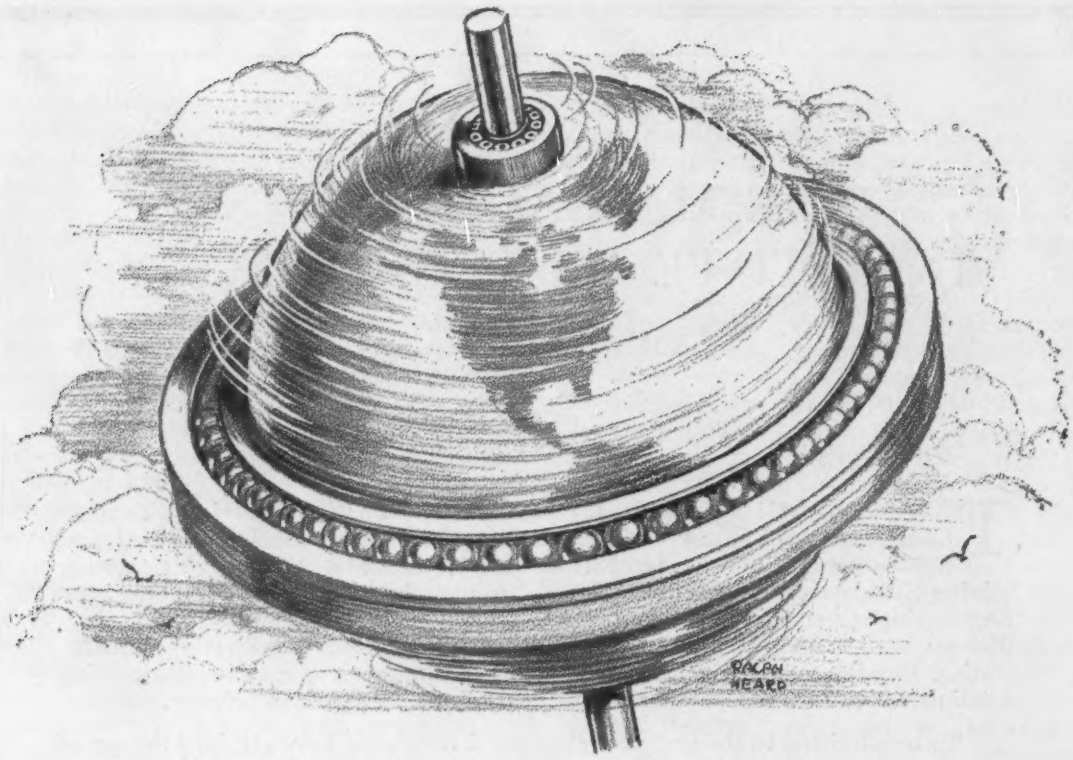

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Many of these plants are equipped with Norton Grinding Machines. Many of them use Norton Grinding Wheels and Alundum Polishing Abrasives.

Norton Research Engineers, Chemical Engineers, Mechanical Engineers and Sales Engineers are serving this as well as many other industries, meeting present production needs and studying into ways and means of bringing about greater accomplishment in the days to come.

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Photo by Brubaker Aerial Surveys, Portland, Oregon.

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AT Port Angeles, Washington, stands the mill of the Washington Pulp and Paper Corporation—a mill that produces enough newsprint every day to make a sheet 10 feet wide and 1,000 miles long.

When this great industrial organization built a mill extension that almost doubled its capacity, Westinghouse, having already supplied electrical equipment for the original plant, was called on to electrify the new unit. Difficult driving problems were met and solved by Westinghouse engineers—with individual motor drives up to 1000 horsepower, with refined control mechanisms, with the sectional paper machine drive that has revolutionized the making of this important product.

Big jobs go to big organizations. Westinghouse attracts young men of enterprise and genius because it daily provides facilities and opportunities which smaller corporations can seldom offer.

, , ,

The Washington Pulp and Paper Corporation's mill represents the most modern and scientific application of straight line production to the paper industry. Pulp wood enters one end of the long building on an electrically powered monorail carrier. It follows in a continuous line through the grinders, screens, mixers and jordans to the paper machine. At the other end the finished paper is rolled and wrapped for shipment. Power for every operation is supplied by electric motor.

Westinghouse

PRECISION

One-fifth of a Tenth of a Thousandth of an Inch

A RATHER insignificant item in everyday student life—but in the making of New Departure ball bearings, a unit of measurement of real importance. The steel ball in a New Departure Ball Bearing has a sphericity as close to dimension as any standard known to man—far closer than anything else manufactured commercially.

To check its variation from perfect sphericity accurately would require a gauge capable of measuring *to the millionth of an inch!*

All parts of a New Departure are made to such precision limits, that the accumulated error of parts, ball races and balls, will not total more than two ten thousandths of an inch. Thus it is that the ball bearing can support most accurately the rotating shaft or spindle of a machine.

The next discussion will deal with the *strength* of the New Departure steel ball.

THE NEW DEPARTURE MANUFACTURING COMPANY
BRISTOL, CONNECTICUT
Detroit San Francisco Chicago
Division of General Motors Corporation

New Departure

924

Ball Bearings

When a full blooded American Indian was the world's champion athlete

When Jim Thorpe won the Pentathlon and Decathlon at the Stockholm Olympic Games in 1912, the world was electrified. By securing a majority of points in broad and high jumps, discus and javelin throwing, putting the shot, running races and dashes, Thorpe was awarded the title of World Champion.

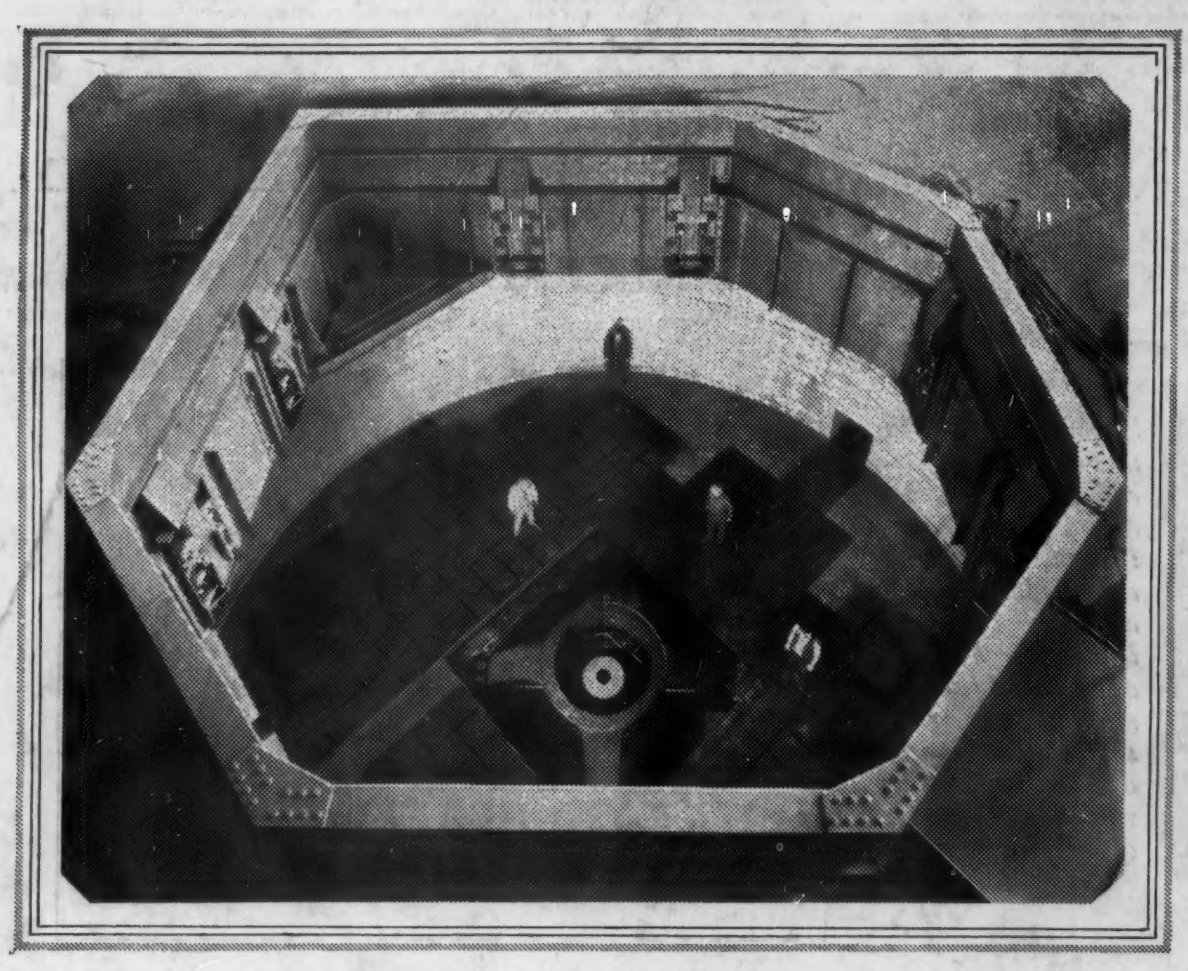
THE 1928 Olympics will be in Amsterdam. One of its show places is the magnificent new Bank of the Netherlands Trading Co. No doubt this bank would be proud to have one of Holland's native sons win world fame similar to Thorpe's, but they do not believe in compelling clerks to practice marathons and weight lifting in their daily work.

You will find in this bank 24 Otis Elevators of the most modern type from the micro-driven passenger elevators that annihilate time and space in their 100 foot lift, to smaller elevators and dumbwaiters that carry valuables and strong boxes, books and safes, ashes and food—elevators of every type and purpose—all products of Otis.

It should be a real thrill to visiting Americans to contemplate one of America's great industries as a necessary adjunct to the march of civilization—even in countries of the old world that were making history when American Indians were yet to look upon the face of a white man.

OTIS ELEVATOR COMPANY

Offices in All Principal Cities of the World



The Pit

Three feet of concrete—seven of sand—five more of concrete—all reinforced with steel—such are the walls of this underground chamber. The roof, a slab of steel rimmed with girders, is held in place by great steel wedges.

A military stronghold? No—a test pit at the Schenectady Works of the General Electric Company. Here the "test men", young engineers, most of whom were in college only last year, help test the rotors of waterwheel generators for safe operation under emergency conditions. These rotors—some as large as 40 feet in diameter—are revolved at double the speed which will be demanded of them in normal service.

The pit controls, located in a building 300 feet away, are supplemented by ingenious listening and visual devices which give accurate indication of conditions in the pit at any instant.

Such elaborate precautions have been devised because of the immense size and power of generating apparatus which is now being built to answer the general demand for more electric energy. Scientists and manufacturers are establishing new standards of electrical production—building a heritage which will aid the engineers of to-morrow to increase the usefulness of electricity far beyond to-day's limit.

General Electric's record for successful performance of its waterwheel generators is only one of the things that have given meaning and value to the G-E monogram, which appears on all the equipment built by the Company.

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GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK